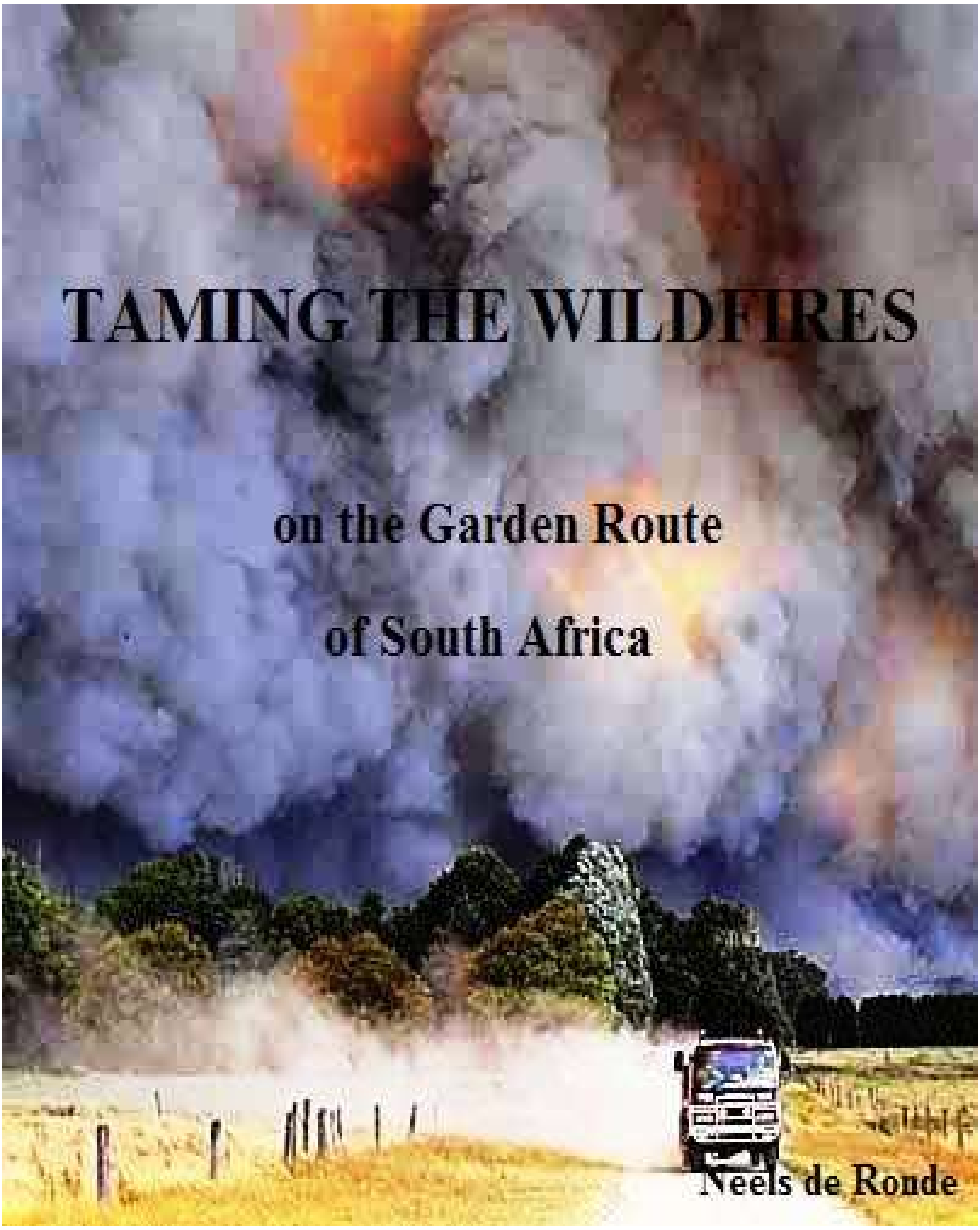
TAMING THE WILDFIRES
on the Garden Route
of South Africa
Neels de Ronde

ABSTRACT

MEDITERRANEAN ZONE-BIOME WILDFIRES

THE SOUTH AFRICAN GARDEN ROUTE FIRES: EXPERIENCE AND USE

The escalation of catastrophic wildfires is a growing global problem, particularly in the Mediterranean Zone-biome countries and related regions, with near-similar climatic conditions and vegetation bases. Today the wildfire situation has reached alarming proportions, leaving human populations completely helpless and in a "panic stations' mode".

Climate change is having a dramatic effect on the Mediterranean Zone-biome regions, from California in the western States of America to Australia, via e.g. the South African coastal fynbos shrubland domain, and Southern European countries. Historic research results were thrown overboard or just shelved, and the "fire exclusion" policy has been winning ground in many quarters, at the expense of pressing fire-ecological requirements.

It is also clear that climate change is having the worst impact on Mediterranean-type climatic conditions, where some of the most dangerous fuel accumulations were allowed to develop unchecked, presenting a frightening "platform" for the ignition of extreme Mega-fires.

This book will be looking at the South African perspectives. Here, along the Southern Cape regions of South Africa, we have reached a crossroad situation and what I want to present here, is "the way forward" and – most important - how the existing local knowledge base can be extrapolated and put to good use to other international wildfire "hot-spots".

The steady increase in fire exclusion caused a dramatic increase in available (dry) fuel loading within the fynbos shrubland in particular, which dominates the Garden Route landscape of the Southern Cape regions of South Africa. Adding to this explosive situation, we experienced a steady increase of exotic weed levels within the fynbos shrubland, and we are subsequently just waiting for the wildfires to provide a (forced, detrimental) solution to this added problem. ***Now that climate change is a reality, we are even faced with disasters of unheard proportion much sooner than we may think would have been possible.***

During 2007, another region of South Africa (the Mpumalanga Province) was mostly destroyed by a number of extreme wildfires around the village of Sabie. To meet future wildfire threats, a range of regional buffer zones have been created in the landscape, to counteract this growing problem. Fire protection was further strengthened by yearly-applied prescribed, applied to thousands of hectare of montane grassland, savanna and industrial Pine plantations in that region. This concerted action reduced wildfire damage substantially since then. Now, twelve years later, we can show the world that this clever and systematic fuel

management program – based on fire-ecological principles – is not only feasible, but that it effectively manages dangerous fuel levels!

Sadly, the same fire-application rules were not applied in the Garden Route region, and most controlled fire application was excluded from its fire-related ecosystems, with devastating results! This dangerous situation was allowed to develop in this region, regardless the evidence of decades of fire-ecological and fire management research programmes, stipulating the role of fire-use in the region.

Yes, one of the proposed measures will be to re-introduce a number of prescribed burning regimes to the region, but this time also incorporating features in the landscape such as favourable topography for fire application, constantly flowing rivers with non-burnable riverine vegetation, and natural vegetation, where fire is needed to maintain the biodiversity of vegetation communities.

Yes, there will be some shortcomings in funding to provide and apply such a comprehensive regional fire prevention plan, and restrictions in Legislation will have to be overcome by means of adjusting or rewriting existing, fire-related, Acts. Most of all, the attitude of the decision-making leaders will have to be changed drastically, with full support for these changes right from all top management and at all Government levels: We also have to sort out "which" organization will be responsible for "what", regardless which management structure is doing this now. I will address this thorny issue as well in this book, looking at restructuring requirements in the process.

Are we up to it? Well, as our late South African President, Nelson Mandela, so wisely said, "It seems impossible until it's been done!" I have full confidence in my fellow-South Africans to be up to such a challenge, as we have confirmed by winning the latest International Rugby World-cup for the third time, against all odds.

This "book direction" can also assist in e.g. Chaparral fuel and fire-related management, because these ecosystems belong to the same family as our fynbos shrubland base. So, indirect extrapolation will be possible, with some adjustments for local conditions.

Decades of fire exclusion caused a terrible, extreme, fire hazard mess, aggravated by real-time climate change now catching up on us. However, it will greatly assist if interesting persons could at least read this book and then see where this material could assist in finding a solution for the Californian wildfire problem, just to mention one international extrapolation potential. Most important: The decision-makers must get the message and understand the implications if we do not move in this direction, fast!

I do not have to re-invent the wheel to compile this book, as it basically consists of my own experiences and existing databases, which I developed globally with others over more than forty years of research and fire management experience.

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PREFACE

"Prevention is better than cure": This is also very true in the case of Mega-wildfires. Once a roaring wildfire escapes and "takes off" under adverse weather conditions, all the fire brigade machines, water bombers and thousands of fire fighters are helpless in stopping such fires!

Another contributing factor to uncontrollable fires is climate change – with its extreme climatic conditions – which is not only a reality today, but is here to stay and get worse!

Add to this the assumption of the public at large and authorities in the Cape Regions of South Africa, to rather ***INCREASE fire exclusion systematically and DECREASE controlled fire use,*** and it becomes clear that we are here sitting on a time bomb! How does this situation compare with other regions around the globe? Here follows an example from some years ago::

The Southern part of France (the "Rivièra") was approximately twelve years ago shocked by a terrible wildfire in their mainly "Maquis" natural shrubland-covered landscape. The fire started high in the mountainous terrain, and was only stopped the moment the fire ran out of fuel, when it reached the shores of the Mediterranean Sea, after burning-out one of the region's prime conservation areas.

The local decision-makers decided to call in international experts from various corners of the world - where similar natural shrubland communities grow - to attend a workshop *in loco* to assess and address this serious problem, and to reduce similar re-occurrence probabilities.

So I was also selected to represent South Africa (from the region mainly covered by the fynbos shrubland), together with an Australian (representing the Western and Southern Australian shrubland), a scientist from Portugal ("Arbustos" shrubland) and a scientist from the California State of the USA ("Chaparral" shrubland), together with representatives from other regions in France, facing similar wildfire threats.

It soon became clear that consensus had been reached, with selecting the use of prescribed fire as a fuel management technique, as this was seen as the answer to the wildfire problem in this region of France. There was one exception though: The representative from California (Chapparal), who strongly believed in fire exclusion as being the one and only (ecological) solution. He advocated that the use of fire as a management tool should be avoided at all costs. He could not explain, however, what should be done about the management of subsequent increased fire hazard though!

About twelve years later extreme wildfires occurred in the State of California at regular (mostly yearly) intervals by then, getting from "bad to worse" each year in terms of homestead burnouts, mortality and forced evacuations, hitting the international news headlines many times, more than in any other region.

I fail to understand that some people just ignore the important role fire plays in our natural vegetation as well as in our "industrial" timber plantations in the Garden Route region, and in some other global Mediterranean Zone-biomes, such as in California (USA)*. Locally, decades of research underlined the important role of fire in our natural ecosystems,(such as in fynbos), in the Cape Pine plantations as well as the use of fire as a selected management tool to combat the spread of some fire-related indigenous and exotic weeds.

Why was this knowledge base ignored by most locally? I am sure there are some people who will take my notes at heart and are prepared to "face the flak" and try to do something about this heartbreaking threat for the future existence of this "jewel of South Africa". I know there are even some decision-makers that agree fully about the vital role prescribed fire can play in our region. However, when faced with the "mountains" of financial resources and professional manpower constrains, the general negative thinking of the public at large, and the problems envisaged when attempting to "sell" these drastic measures to Government institutions, their hearts will most probably just sank into their shoes, and they do not even try to convince their superiors in the Cape regions? Do we blindly ignore the terrible wildfire disaster threats? Also, why do we close our eyes when it comes to drastic measures required to meet these challenges, because "this might not meet our financial budgets", or "fire prevention measures might not meet linked demands?" Are we falling in the same trap as our "Californian friends?"

The South African scientists have earned the name of being the first to research the role of fire in our natural ecosystems and lately also in our imported exotic Pine stands, providing acknowledged international fame in these well known fields of research. Has all this unique work gone down the drain in favour of the fire exclusionists' policies, and are we on our way back to "square one?"

What are the decision makers trying to do by clapping participants of "fire meetings" on their back when they table the solutions to the "wildfire problem" in our region, and that they stayed "within limits of budgets" and "manpower constrains". Who are they really trying to bluff when they state that "these measures will be the ultimate solutions to the growing wildfire problems???"

With this book I will attempt to open my heart for the public at large, decision-makers, fire managers, fire fighters and whoever else reads this. I am not working for a boss anymore and do not owe this region anything, apart from one single most important issue, which is:

*=On the positive side though, I believe there is a "turnaround" in California, and that a prescribed burning programme is now planned at last to apply such fire-use with immediate effect.

That I write this book because I love this area where I lived most of my life, its natural beauty and its inhabitants. It breaks my heart to observe that the size of wildfire disasters within the Garden Route region is growing exponentially in our “Garden of Eden”, and I am dedicated to at least put my thoughts on record.

I am sure there are some people who will take my notes at heart and are prepared to “face the flak” and try to do something about this heartbreaking threat for the future existence of this “jewel of South Africa”. I know there are even some decision-makers that agree fully about the vital role prescribed fire can play in our region. However, when faced with the mountains of financial resources and professional manpower constrains, the general negative thinking of the public at large, and the problems envisaged when attempting to “sell” these drastic measures to Government institutions, they most probably feel like “throwing in the towel” and do not even try to convince their superiors.

Regardless this general negative attitude, also on the positive side though, I have mention that I have taken note of some good block burning exercises in the region recently, which should be applauded and seen as positive “first steps” for successful regional fire prevention. However, sadly I am still seeing these blocks as creations of “prescribed burning islands” where mega-wildfires will still have a “walk in the park”. There is sufficient room for improvement here, but then according to a motivated regional fire prevention plan. Problem is, who will take the lead, have the guts and will to brush all the negative thinking aside at regional level? I will address these questions under Chapters XIX and XX.

By writing this, I will try my best to present my thoughts where necessary based on research findings, but then in such a way that “the man in the street” can understand the meaning of the text provided. Because some of the readers might have an interest in science-related information in this book, I will provide some key references to facilitate further spread of this information, and to encourage scientific literature searches for background reading. In this way, the readers will have to accept the integrity of my information resources as well as my own research findings, where this was in some cases never published in the form of scientific publications.

I will attempt to present the material, in a basic understandable form to the best of my ability, so all can follow this. In this way, I will try to provide with this book a compromise between scientific writing and a non-fiction book approach.

With this book I will explain the drastic measures that will have to be applied to meet the extreme wildfire threats facing the Garden Route and surrounding regions, as has been the situation right now in US States such as in California at the time of writing, and also lately e.g. in the States of New South Wales, Queensland and South Australia, in Australia. Here millions of people are threatened by wind gusts exceeding 150 km/hour, thus conditions where fast evacuations of millions of people are now a nightmare becoming reality.

CHAPTER I

INTRODUCTION

1.1 A global perspective

The escalation of catastrophic wildfires is a growing global problem, particularly in the Mediterranean Zone-biome countries and related regions, with near-similar climatic conditions and vegetation bases. The wildfire situation has today reached unheard of proportions, leaving human populations completely helpless and in a panic-state. Politicians are today pointing fingers at every discipline involved, regardless whether they understand the underlying reasons for these disasters or not, let alone to provide solutions (or at least directions to solutions) for these international threats.

What is worse, we appear to have lost the will to meet these global challenges in the regions which were hardest hit by extreme wildfires recently, such as California (USA), New South Wales (Australia), some Mediterranean countries (Southern Europe), Chile and the Cape coastal regions (South Africa). The human race is losing direction in understanding the role of fire in ecosystems regardless the existing research history in these fields, and is close to reaching a "giving-up mode" when extreme climatic conditions occur as a result of climate change.

It is clear that climate change is having the worst impact on Mediterranean-type of climatic conditions, where some of the most dangerous fuel conditions were allowed to develop unchecked, presenting a frightening "platform" for unheard of "fire storm-situations". Have we lost the will to survive in the Mediterranean Zone-biome and related regions? What has happened to human beings' will to survive under changed climatic conditions? Have we lost the will and the guts to meet those challenges?

This book is looking at the South African perspectives, where extreme wildfires were experienced and where we have also reached a crisis situation in failing to meet the changed climatic conditions and threatening fire exclusion situations in explosive fuel conditions. Here, along the Southern Cape regions of South Africa, we have reached a crossroad as has also been reached in other countries at global scale, and I want to write down "the way forward" and how the researched base of methodology can be extrapolated to other international "hot-spots", as the way to go.

1.2 Local background

During 2017 and again during 2018, a range of extreme wildfires devastated the Garden Route region of South Africa. During 2017, more than 1000 domestic homes were destroyed in and around the Knysna Municipal land, when a total of more than 30 000 ha of the landscape there was burned over. During 2018, an even more severe number of wildfires burned more fynbos shrubland of the Outeniqua Mountains along the Garden Route, but fortunately less man-made structures were lost this time. However, a total area exceeding 100 000 ha was burned.

The 2017 wildfires penetrated the Knysna Urban Interface, where little or no attention was in the past given to within-Urban township housekeeping; many houses having been built right inside dense fynbos vegetation. During the 2018 wildfires, less structural damage was experienced, but one rural settlement was completely gutted, with a sad eight lives lost. A sawmill was also destroyed by this fire, which had serious industrial consequences, also for related unemployment.

For various ecological and fuel management control reasons, the dominating fynbos shrubland, covering the Outeniqua Mountains and adjoining plateau, was 3 – 4 decades ago mostly regularly controlled-burned in the form of block-burns. Unfortunately, this controlled ecological/fuel management burning programme was - from the 1970's until today - systematically reduced for a range of non-formulated objectives, when prescribed burning was eventually as good as completely terminated during the start of the 21st Century. This then resulted in very old shrubland entering the dangerous "senescent growth phase", when any controlled fire-use would just be too dangerous to apply. Today this vegetation is just waiting for an extreme wildfire to explode beyond control, causing a detrimental fire behaviour which will hurt the maintenance of biodiversity adversely. In a nutshell, this is why the 2017 and 2018 wildfires were experienced.

This steady increase in fire exclusion caused a dramatic increase in available (dry) fuel loading within the fynbos shrubland, which then dominated the Garden Route landscape. Adding to this explosive situation, we experienced a steady increase of exotic weed levels within the fynbos shrubland, and we were simply waiting for the wildfires to provide a (forced) solution to the problem. ***Now that climate change is a reality, we are even faced with a higher probability of having to face a disaster of unheard of proportion, sooner than we may think is possible.***

1.3 The solution

During 2007 another region of South Africa (in the Mpumalanga Province) was destroyed by a number of extreme wildfires, and since then a range of regional buffer zones were constructed in the landscape, to counteract this threat, strengthened by prescribed burning of thousands of hectare of montane grassland as well as forest floors inside industrial Pine plantations. This action reduced wildfire damage substantially since then. Now, twelve years later, we can show that this clever and systematic fuel management program – based on fire-ecological principles – works!

Sadly, the same rules were not applied in the Garden Route region, and most controlled fire was excluded from its fire-related ecosystems in this region, with devastating results! This regardless the evidence of decades of fire-ecologically and fuel management-related research programmes having been conducted, stipulating the role of fire in the region. I will not even attempt to point fingers to why this fire exclusion policy failed, but I will attempt with this book to provide some answers to the wildfire problem in simple – but direct - terms, based on past and existing (on-going) scientific programs and publications.

Yes, these new measures will re-introduce a prescribed burning regime to the region, but this time incorporating features in the landscape, such as favourable topography, constantly flowing rivers with non-burnable riverine vegetation, and natural vegetation where ecological reasoning, is known to require fire anyway. Existing (fuel-free) public road systems will also be strengthened with prescribed burning application, and integrated into all created regional buffer zones in the landscape, combined with incorporation of wildfire history, and many more related fuel management measures.

Yes, there will be shortcomings in funding to provide such a regional fire prevention plan, and restriction in Legislation will have to be overcome and existing fire-related Acts will have to be re-written and - most of all - ***the attitude of the decision-making leaders will have to be changed drastically***. Some urgent advanced training requirements will have to be arranged to equip our fire managers for such a mammoth task, particularly in simulating fuel and related fire dynamics, for a range of fire prevention-related purposes.

Are we up to it? I have full confidence in my fellow-South Africans to meet such a challenge.

1.4 Meeting the world's wildfire problems

With this handbook I will attempt to make it possible for all readers to extrapolate its contents at international levels, starting with South Africa this time, where I will try my very best to get the ball rolling. Globally, I will at least attempt to sow some "fire seed" for those in need. However, my heart goes out to our Californian friends in the US, to name just one example where a whole State can be regarded as being "helpless". How is the situation in Southern European countries? Some are more advanced than others in the use of prescribed burning application, so it is difficult to generalise. However, some countries where "fire exclusion" reigned experienced recently terrible the worst wildfires, and they are now fast considering more fire-use as a matter of top priority!

This "book directive" can indeed assist with the management of Chaparral as well as Southern European shrubland fuel levels, because these ecosystems belong to the same family as the South African fynbos shrubland. So, indirect extrapolation will be possible. This will be so much easier for scientists and technicians in the US, because they developed the basic knowhow in the form of computer-based fire behaviour simulation programs, arriving at a system I also used to advantage to develop, test and apply to create a South African custom fuel model database for local vegetation. This I have been using to advantage for fire behaviour prediction, the calculation of buffer zone effectiveness, fire hazard rating and mapping, and much more other uses. In the USA you have the added advantage that experienced experts are readily available, right there on site!!!!

I am not going to even try to find the reasons for the terrible wildfire problems in the USA, in States such as California, but one thing is clear: Decades of fire exclusion caused this terrible mess, aggravated by climate change extremes. I believe in other States controlled burning program were applied for decades now very successfully. However, it will assist if you could at least read this book and then see where this material could assist in finding a solution for the Californian wildfire problem.

I do not have to start new research programmes to compile this book, as it basically consists of my own experiences and databases, which I developed over more than forty years of research and fire management experience at global level. However, comments will be welcome at this early stage, particularly in marketing this book as widely as possible, to assist me in getting the message to all corners of the fire world. My book could be ready by early 2020.

Please assist me in "killing" stories such as that "Californian fires cannot be stopped" and rather consider the proposed "Billion Acre Prescribed Fire Management Plan" suggested for the Western States of the USA recently. I know that the Garden Route proposals can be extrapolated to any global corner of the world, although some vegetation community fire-related (such as available for the South African fynbos Kingdom) can best be related to e.g. Chaparral in the USA as well as the Mediterranean shrublands in Southern Europe.

To Summarise:

(a) The wildfire problem in Mediterranean Zone-biome regions has increased exponentially during the past five years.

(b) It was re-affirmed that fire exclusion is not an option in the Mediterranean Zone-biome regions and that the use of fire as a fire management tool for regional fire prevention is the only solution to meet the wildfire threat effectively. Such prescribed burning programmes will be based on fire-ecological principles, determined over decades of fire-related research.

(c) To be effective against wildfires – particularly in the light of climate change – "clever" prescribed burning programmes will have to be applied, to form effective regional buffer zone lines in the landscape, to restrict wildfire spread and avoid just creating "prescribed burning islands".

(d) To provide advanced training demands required, to meet effective operational needs, for increased and effective fire prevention measures.

Photograph 1. Wildfire in progress, burning in mountains near Somerset West, near Cape Town, in South Africa (Picture take by C. de Ronde).

CHAPTER II

VEGETATION BASE OF THE SOUTHERN CAPE, AND CAPE PINES

One of the most critical problems with wildfires is the lack of understanding - and absence of reliable prediction - of fire behaviour. Even experienced fire bosses only base their "fire experience" on visual observations, which cannot be quantified in terms of fire behaviour parameters. Many times they do not even know what parameter(s) should be used or observed for such assessments.

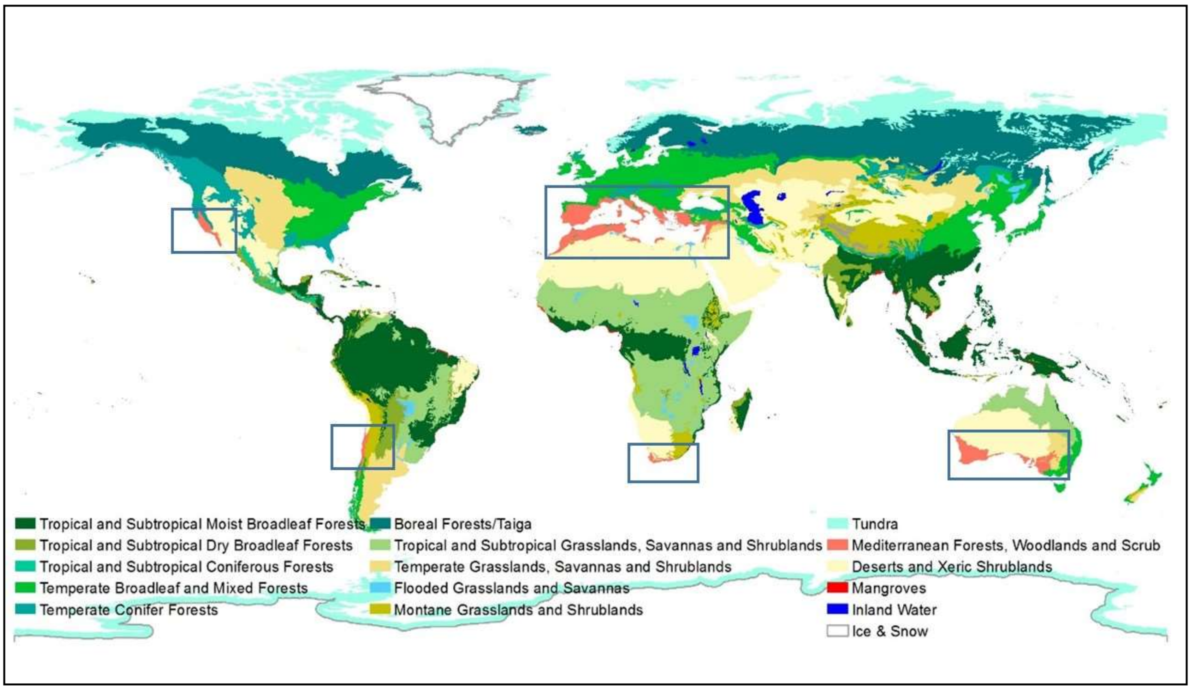
The researched truth is that fire behaviour prediction can only be assessed as close as possible to real-time fire behaviour, by means of simulation from suitable computer-based programs, making it possible to measure and quantify e.g. the five main fire-related parameters. Such simulation exercises can only be conducted when certain vegetation information can be readily collected - or be available in databases - for input purposes.

What is the bottom line? This will first of all be to obtain a basic knowledge of vegetation/fuel dynamics. Without such information, no meaningful determination of (as-close as-possible-to-real-time) fire behaviour can be obtained.

2.1 Fynbos

Together with Afromontane forest, fynbos shrubland forms the most prominent natural vegetation biome in the Western and Southern Cape higher rainfall regions in South Africa, including in the Garden Route area. Map 1 illustrates where fynbos occurs within the Mediterranean Zone-biome, as indicated.

Many of the most serious wildfires are historically experienced in the Mediterranean biomes, but lately occur there at an increased rate, where the most prominent natural vegetation type fuel bases need fire to maintain biodiversity. However, most vegetation within these biomes was excluded from fire. Examples are e.g. the coastal areas of the Western Cape Province (fynbos shrubland), the coastal region of Western California (chaparral shrubland) and coastal zones of countries such as Portugal (arbustos) and Greece (phregana). In Chile the prominent (fire dependant) vegetation cover consists of exotic Pine stands, mostly *Pinus radiata*, while their natural shrubland is mostly not fire dependent.



Map 1: Changing fire regimes are observed throughout the Mediterranean Zone-biome in Europe, Africa, the Americas and Australia (unknown source).

The fire ecology of fynbos has been well studied, especially from the 1980's onwards. During the earlier years of the twentieth century, fire was seen as a damaging influence on the biota by most biologists at the time. This view began changing by the 1950's and there is now widespread recognition that a great many fynbos plant species require fire to complete their life cycles (Bond *et al.*, 2004).

The most prominent sub-fynbos biome classes found in the region are Renosterveld (extreme western part of the region, north and west of Mossel Bay) and the Strandveld (coastal dune areas on the plateau, closer to the Indian Ocean). Renosterveld covered land has in this region been mostly ploughed for agricultural purposes, with only fragments of Renosterveld remaining on the plateau.

Strandveld differs from fynbos and Renosterveld in that its dominant elements are fire-avoiding. These are broad-leaved evergreen shrubs and small trees forming patches of thickets and scrub forest. The broad-leaved thickets intermingle with elements of fynbos and Renosterveld (Bond *et al.*, 2004). Many Strandveld areas have today been taken over by dominant weeds such as Rooikrans, and these invasions increased fire hazard significantly in these coastal areas, because of their high rate of dry fuel development.

Photograph 2. Fire in fynbos vegetation in the Western Cape. Source: Unknown.

2.2 Afromontane forests

Afromontane forests, in contrast, are being threatened by fire and by man. Subsequently, sites where fires are excluded for 50 years or more can provide favourable conditions for forests to expand provided forest edges are well protected against fire and exploitation damage, well into the first years of regeneration. Property owners and caretakers of Government land are thus encouraged to protect forests on their properties to the best of their ability.

Generally speaking, non-degraded Afromontane forests do not readily burn due to their structure, separation from the litter layer and their higher fuel moistures (van Wilgen *et al.*, 1990). However, unfortunately most forests are threatened by fire because of some degree of damage as a result of timber exploitation, or fire damage of the forest edge. Often areas of fire-prone vegetation exist adjacent to Afromontane forests, and frequent fires can "eat away" at the forest margin.

Many of the forest tree species have not adapted to fire and are sensitive to its impact, except for a few deep-rooted trees most of the overstorey trees are killed by ground fires (Geldenhuys, 1977). Property owners and managers in control will thus have to apply special measures to protect our Afromontane forests in the region, which includes scrub forest, particularly where such forests are situated along strategic lines in the landscape and can be integrated in regional fire prevention buffer zones to *add* to improve fire protection.

Scrub thickets and forests can also be found in larger areas on the lake-covered plateau, and are normally not presenting a serious fire hazard, apart from during the growth stage when this reaches the senescent phase. Then mortality among seed-generation accelerates, foliage on survivors is reduced to tufts at tips of branches and crowns become more open. Litter and dead shoots then continue to accumulate and fire hazard subsequently increases (Kruger and Bigalke, 1984).

Photograph 3. Afromontane forest edge near Groenvlei, (east of Sedgefield), which is here closer to a scrub forest-form (Picture taken by C. de Ronde).

2.3 Exotic weeds

Alien exotic weeds can significantly increase in population following wildfires on all fynbos-covered land and it is necessary to map such major invasions on regional vegetation/fuel maps. In the mountains such exotic invasions include *Hakea sericea* and *Pinus pinaster*, while in Strandveld, *Acacia* weeds can dominate coastal land (van Wilgen *et al.*, 1990).

It is in particular the Strandveld fynbos which can be significantly infested by *Acacia* weeds, resulting in the natural fynbos as good as disappearing from such sites. This has to be subjected to intensive follow-up weeding to be applied with prescribed burning of the weed slash with follow-up weed eradication processes, to convert such areas back to natural Strandveld fynbos again.

2.4 Industrial plantations

Along the Garden Route, industrial (mainly Pine) timber plantations are dominating the landscape along the foothills and on the plateau. Along the foothills, provision has to be made for three categories of plantations, namely (i) plantations excluded from "exit" processes*, (ii) plantations clear felled and converted (or in the process thereof) to fynbos, and (iii) plantations clear felled for conversion to fynbos, but then re-allocated to be established to timber plantations again. At regional level, these three categories (fuel classes) are proposed to be added to the regional maps of the Garden Route for fuel classification purposes, fire hazard rating and fire prevention mapping, with an option to be further sub-divided between (i) having been exposed- or (ii) not having been exposed- to recent wildfires.

Photograph 4. Prescribed burning in progress in a Pine plantation in the Sabie district, Mpumalanga, South Africa Note higher intensity fire experienced in Wattle slash (Photograph taken by C. de Ronde).

The Pine plantations found along the mountain foothills, have mainly been established in the form of even-aged tree plantings, and today mainly exist of two species, namely *Pinus elliottii* and *Pinus radiata.*

*=Ex original Industrial Pine plantations, clear felled with timber exploited, and to be converted to fynbos by means of allowing natural fynbos regeneration to come in after the felling and timber exploitation process. However, if these areas were not cleared from weed, Pine regeneration and slash leftovers will seldom convert to "pure" fynbos because of the lack of tending of these areas, resulting in fire-hazardous vegetation mixtures far removed from "natural fynbos". The future of these "converted lands" is today uncertain.

Based on specific pruning and thinning regimes as well as changes in crown canopy closure with tree growth, the status of litter loading and structure, forest floor vegetation and existence of felling slash leftovers subsequently changes significantly over time until the stands reach clear felling age, when timber is removed and slash remains again change fire hazard status significantly.

The Pine stands found on the plateau have mainly been established with *Pinus radiata* trees, but here mainly by means of natural regeneration. This did create some variation in within-stand tree age, but by following thinning application, these stands were mainly developed as uniform tree stands when mature, but still with mostly partly crown suppression and subsequently patchy forest floor vegetation "islands".

` To summarise:

(a) There is a pressing need for fire managers to better-understand the basic characteristics of vegetation and related fuel, including the role of vegetation dynamics in fire behaviour and fire ecology.

(b) Only by understanding vegetation and fuel dynamics better, will fire managers get a better understanding of fire dynamics and related fire prevention requirements.

CHAPTER III

FIRE ECOLOGICAL REQUIREMENTS FOR THE MAINTENANCE OF BIODIVERSITY

Answering this question remains one of the key issues in motivating fire-use in a particularly type, (i) at what frequency (optimum age) fire has to be applied, (ii) season of fire application and (iii) optimum fire intensity required for maximum results. The "fire exclusers" will be looking for these answers to determine how fire can assist in the maintenance of biodiversity of a specific vegetation type, before they are convinced if fire-use will provide the solution.

There is only one significant vegetation type growing in the Garden Route region of South Africa, which can be considered in its true natural form under this heading, and that is the fynbos shrubland. However, because of their important (partly non-natural) fire-related role in the region, Afromontane forests as well as exotic Pine stands will also be discussed here, because of their fire-ecological role within these two vegetation types, commonly occurring in this region.

3.1 Fynbos

It is hard for an observer to imagine that the blackened waste to be seen after a fynbos fire is merely a stage in the cycle of regeneration and development of such rich and attractive communities. How can such ugly things such as wildfires be required to maintain such a species-rich biome of biodiversity?

Fynbos fuel comprises well-dispersed spread of fire-available material, but this is nevertheless bulky, inflammable fuel in the intermingled herb and lower shrub strata, sometimes up to 1.5m above soil level but usually less than 0.75m above ground.

Fynbos fuels impose a certain character on the fire regime. They are coarser and more dispersed than grassland fuels, and therefore do not burn as fast or as frequently, though productivity may be near-similar. Subsequently, the development of fynbos fuel models will need to consider fuel structure and density parameters very carefully to be representative of a specific fynbos fuel community (Kruger and Bigalke, 1984).

We have to consider certain non-ecological (or adjusted fire ecological) effects in the case of the Garden Route, which will have to be identified, to be differentiated in the regional fuel model set to be developed for the region. Such effects can be: (i) Variation in yearly rainfall levels, (ii) differentiation from Mountain Fynbos in Strandveld and Renosterveld, and then (iii) significant variation in heavily weed infested fynbos, particularly in *Acacia*-infested Strandveld. Apart from these considerations, the following research guidelines will have to be followed when considering optimum controlled burning fire regime:

- FREQUENCY OF FIRES
  Fynbos communities accumulate enough fuel to readily sustain a running fire under average summer conditions once they have reached a post-fire age of four years and may burn at three years under extreme weather conditions (Kruger, 1977). Research results indicate that fire frequencies of 10 to 15 years maintained all species, while more species were eliminated progressively more when fire frequencies exceeded 20 years.

  Subsequently – also considering local variation within the Garden Route region – prescribed burning targets should be applied by means of fire-use between 12 and 20 years (van Wilgen *et al.*, 1990).

- FIRE SEASON
  The maximum flowering activity occurs in late winter or spring (Kruger 1981), which implies that the maximum seed load will be available in late summer or early autumn. Regular prescribed burning outside the late summer-early autumn period could result in the local extinction of species (Bond *et al.*, 1984) and is therefore not usually applied. In the Western Cape region (west of the Southern Cape region) prescribed burning is usually only feasible in March or April (van Wilgen *et al.*, 1990)

  In the Garden Route region (outside the winter rainfall, into the constant rainfall areas) flowering of certain fynbos species could fall outside the winter/spring seasons, because of this seasonal rainfall pattern, allowing variation in optimum prescribed burning at times, although good burning days could in general also be more common during March/April than west of this region (own observations).

- FIRE INTENSITY AND BEHAVIOUR
  Provided the frequency of burning is selected within the recommended 12 – 20 years old period, fire intensity and other fire behaviour parameters should be acceptable for optimum results for maintenance of biodiversity. However, when fire (particularly wildfire experienced during extreme windy conditions) enters the senescent growth phase – particularly when older than 30/35 years of age - fire can have a serious detrimental impact on the maintenance of biodiversity of fynbos.

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Photograph 5. Senescent Strandveld fynbos near Still Bay (Picture taken by C. de Ronde).

3.2 Afromontane forests

.Post-fire changes in structure and dynamics in forests and forest margin (edge) communities are, to a great extent, determined by the adaptive responses of forest and forest margin plants to fire. The typical abrupt margins of many forests whose surrounds are subjected to regular fire, substantiate this (van Wilgen *et al.*, 1990).

The most important contributing factor to fire damage to forest edges appears to be in most cases the degree of exploitation damage by man, to the margins of forests and to what extent ecological recovery mechanisms will allow repair of such damage. This includes the effectiveness of fire protection along such forest edges by man, against future wildfire damage (own observations). The incorporation of such fire prevention requirements into preventive buffer zone systems will thus be a vital issue in fire prevention measures at regional levels.

Each forest should - where possible - be considered to be incorporated into regional buffer zones with as objective to provide a non-burnable link in a buffer zone chain, simultaneously providing some form of protection for the forest edge. This can include scrub forest along north-south-flowing rivers, from the mountain foothills into the Indian Ocean, which are many times providing the core for continuous buffer zone routes on the plateau, combined with public roads, sub-urban areas and plateau fynbos. Larger forest areas, such as the Knysna Forest, can form an integrated fire prevention buffer zone on its own, with added forest edge fire prevention programs.

Photograph 6. Mature Afromontane forest on the Tsitsikamma plateau, South Africa (Picture taken by C. de Ronde).

3.3 Exotic Pine stands

Before discussing some fire-ecological aspects under this heading, it is important to emphasize some facts, namely:

- The original habitat of the trees used locally for Pine tree establishment, require a specific fire regime to maintain biodiversity.
- The trees were established mainly inside the fynbos shrublands of the region, which also require a specific fire regime to maintain their biodiversity in this South Africa region.

Then it is in the Garden Route region that the resistance of the Pine trees to fire damage counts, and which has to be fully understood. This is because we are here not only looking at the resistance of tree species/age to wildfires, but also to prescribed fire-use, which is a vital issue when incorporating these Pine stands within regional buffer zones.

Where are these Pine plantations situated along the Garden Route?

The mostly southerly aspects of the Outeniqua Mountain foothills have a significant area under managed Pine stands, mainly consisting of *Pinus elliottii* and *Pinus radiata*, still mostly under control of the MTO forestry company, but a significant area also under other private ownership.

A significant percentage of these stands will be planned to be incorporated in a west-east regional buffer zone all along the southern mountain foot-slopes. Although the *P. elliottii* stands provide excellent opportunities to be incorporated in buffer zones because of their excellent resistance to fire damage, in contrast, *P. radiata* is susceptible to fire and requires special care when incorporated as part of a prescribed burning programme (e.g. de Ronde, 1983; de Ronde 1988).

On the plateau itself, particularly on the sandy soils of the coastal dunes, it is mostly *P. radiata* that is established as commercial Pine forests. Here mostly natural regeneration is used as a basis for establishment of the trees, apart from the plantations east of Knysna, which are normally planted for re-establishment after clear felling and exploitation of the timber.

What are the most important fire-ecological issues to be remembered when considering species-specific fire resistance features?

P. elliottii:
The species is by far the most fire-resistant tree grown commercially in the region, and its cambium is so well protected under the bark flakes that it can even withstand temperatures exceeding 500^0C for more than two minutes (de Ronde, 1982)

Although the species can only be exposed to mortality when fire reaches into the crowns with a long fire resident time, the trees still have the ability to resprout, even when having been exposed to the fire over a long period of fire-resident time (de Ronde 1983).

Although I normally propose the application of prescribed fire under crown canopy, when the latter is completely closed with almost complete absence of forest floor vegetation, and only a down-type of needle mat cover there, earlier prescribed fire can be applied at a stand age of 5 – 6 years, even with no crown canopy closure, provided only a back fire is used for ignition to restrict crown scorch.

P. radiata:
This species is far more susceptible to fire damage than *P. elliottii*, and cambium damage can already set in at approximately 200^0C when exposed to such heat for 0.25 minutes (de Ronde, 1982). Its crown needles are also more susceptible to crown scorch than *P. elliottii*, because of the small and thin structure of the crown needles (de Ronde, 1983). Also, the crown structure of the species is generally thin and narrow, only allowing crown canopy closure from 18 – 20 years of age and older.

Photograph 7. Backfire of the 2017 Knysna wildfire burning inside a *P. radiata* stand at Kruisfontein plantation (MTO). Note general relative low profile of high intensity fire flames, and a flare up on the right burning in a slash pile. Also note a "ladder" fire on the left in the picture. At this stage the fire front is containable with a striphead fire below the backfire on the left in the picture (source of photograph unknown).

Subsequently, prescribed burning should not be considered before the trees are 18 to 20 years old, and then only once forest floor needles have been raked away from tree stems and then spread, to avoid cambium damage.

Because of the species being susceptible to cambium damage, exposure to a high intensity wildfire normally causes mortality as a result of complete crown scorch as well as cambium damage, combined. One can add to this the doubtful resprouting ability, that mortality probability can also be caused by secondary damage, such as damage from *Diplodia* which can easily set in even when early assessment appears to be in favour of survival (de Ronde *et al.*, 2004).

To summarise:

(a) Under fire managers, there is a pressing need for a better understanding of fire ecological requirements of the main regional vegetation bases, and how to work towards such goals within fire prevention plans

(b) Fire managers should also have some basic knowledge of fire behaviour requirements and how to work towards these goals, in tandem with effective fuel management and fire prevention.

CHAPTER IV

EXOTIC AND INDIGENOUS WEEDS AND INDUSTRIAL PLANTATIONS

The impact of wildfire on weed infestation is one of the key issues in assessing wildfire effects. Unfortunately this aspect is also the least researched and it is thus first of all necessary to take stock of what past research has achieved, before plunging into solving this problem area. However, new research work might be required.

I have also categorised "industrial plantations" also under this chapter, as we need to determine if the forestry industry as a whole has a place in this region, in the light of some biologists characterising the whole industry as a threat to the maintenance of biodiversity of natural biomes in the region. The question to be answered is: "Are Industrial Pine plantations still presenting a threat to adjoining biomes?" If the answer to this question is "yes", can the problem be solved to allow a place for both nature conservation and plantation forestry in the landscape?

4.1 *Gleichenia polypodioides* (Kystervaring)

The presence of patches of this indigenous fern in old fynbos indicate that such a fynbos community is far developed into the "senescent" age group, with age exceeding 25 years, with open crowns, a high percentage dead ("available") fuel and very fast drying rate when exposed to wind and sun. This situation can only result in extreme fire behaviour when exposed to fire ignition and able to maintain such a fire, and subsequently will result in adverse fire effects because of exposure to very high fire intensity with a long "fire residence time".

Whenever bright green patches of this fern become visible in the mountains from a distance, such a sites should be prescribed burned as a matter of high priority, considering that this will have to be applied under warm to hot conditions, but preferably without any significant wind, as it "either burns not at all, or it burns like hell" (findings from a US scientist visiting south Africa).

When such a controlled burn is thus attempted, extreme care should be taken of adequate width of firebreaks to be prepared and stable, wind-free conditions, when the fire is applied. Care should also be taken that the backfiring burning method is always applied where possible, with the only alternative being the application of circle or strip head firing. Deviation from backfiring can also result in Kystervaring patches not being completely consumed by the fire, leaving a dead fern mat behind, which will restrict fynbos regeneration (own observations).

4.2 *Hakea sericea*

This exotic weed has invaded mostly the northerly aspects of the Outeniqua Mountains, where some success has been achieved with the introduction of a biological control agent. However, a survey will have to be conducted to determine to what extent the species' regeneration has responded to the 2018 wildfire (own observations).

When eradicating the species, changes in the fuel properties will result. Dead plant material adds to the fuel load and such loads are concentrated close to the ground. Unnaturally high fuel loads lead to detrimental effects on the vegetation following fire, and this has to be prevented. For example, where fuel loads are high following clearing operations, it may be necessary to burn under moderate conditions to reduce impact of higher intensity fires (Richardson and van Wilgen, 1986). This further reduces the number of burning days available for burning or forces managers to burn in spring to complete programs.

4.3 *Pinus pinaster*

This exotic *Pinus* species was one of the first to be introduced to the Southern Cape region of South Africa as early as during the late 19th Century. Unfortunately, different races and strains of the species were planted, some of which are today known to be strong cone producers and seeders. The species subsequently developed into a serious weed inside the fynbos of the Outeniqua Mountains. During the past two decades, the species was faced-out and replaced with mainly *Pinus elliottii*, which does not present any seed spreading ability. However, "mother trees" of the *P. pinaster* are still presenting a weed problem, and subsequently original "seeders" will have to be monitored for seed regeneration as a result of the 2018 fire.

4.4 *Pinus* spp and industrial plantations

Fortunately fresh spread of *Pinus* seed from industrial timber plantations can today be regarded as rare, as *P. pinaster* has been as good as removed from commercial forestry in the region. This makes it possible for weed control programs to concentrate on the systematic eradication of freshly-regenerated seedlings from existing sources as the timber plantations are thus not presenting a fresh threat of added weed problems on plantation boundaries. This means that foresters can now be held responsible for any new future weeding problems, and conservationists do not have to point a finger at plantation forestry anymore about weed spreading problems from these quarters, and the industry and nature conservation can both operate independently from each other to tackle the problem.

The confusion of the "exit" plantation stands (plantations to be converted to natural vegetation) is still doing a lot of damage to both the nature conservation land as well as forestry plantations, and the sooner this harmful programme can be stopped and finalised the better. The damage has been done unfortunately and extremely dangerous fuel additions of these sections of land will require added fire prevention measures and fuel reduction programmes.

4.5 *Acacia* spp.

Between Great Brak River and the western townships from George, riverbeds have over decades been invaded with *Acacia mearnsii* (Black Wattle) in very difficult terrain, making effective control basically impossible over property boundaries on the plateau. Subsequently, such hazardous areas should be as much as possible isolated and systematically be reduced by individual property owners, not to present a source for wildfires under extreme weather conditions.

Acacia Cyclops (Rooikrans) has been identified in certain Strandveld fynbos areas as a serious weed, taking over natural fynbos completely and creating extreme fire hazards in the process, which can only give rise to extreme wildfire damage, eradicating any possible natural fynbos regeneration by decades (own observations).

Acacia melanoxylon (Blackwood) was originally planted inside indigenous Afromontane forests in the Garden Route region, to establish re-growth there. These trees have now been mostly felled with timber removed, and converted back to forest by allowing natural forest regeneration to fill these gaps. No weed threats were caused otherwise created within these forests, but where the trees were planted on forest edges, some restricted seed spread of the species was caused, mainly on private land. No further significant spread of the species is expected after the 2017 and 2018 wildfires.

To summarise:

(a) The impact of wildfire on indigenous and exotic weeds within specific biomes is not well known, and subsequently the methods to combat further weed spread cannot be determined, predicted or quantified with confidence.

(b) How and when to use controlled fire to combat fire-triggered weed regeneration has not been well researched and subsequently fire as a weed management tool cannot be optimised. It is important that we learn to use the existing knowledge-base to advantage to optimise fire-use for this purpose.

Photograph 8. A natural Strandveld fynbos site heavily infested with *Acacia Cyclops* (Rooikrans) eight years after having been exposed to extremely-high fire intensities, with a long fire resident time. Note the complete absence of fynbos regeneration eight years after this fire, confirming the serious detrimental effect of this infestation by Rooikrans and serious impact of this fire on the maintenance of biodiversity of this natural Strandveld.

CHAPTER V

FIRE USE OR FIRE EXCLUSION?

This aspect remains a "burning question" all over the globe, and the answer will be what evidence we have collected to date to prove either the one or the other scenario.

Again, we cannot generalise on this sensitive issue, and we have to decide about a region-specific vegetation/fuel classification by biome or sub-biome, and then answer this question for each vegetation type based on past research findings.

I mentioned earlier in this book that one of the cornerstones of the new regional fire prevention regime for the Garden Route region will be to re-introduce a prescribed burning program. This is, however, not as simple as it appears to be at first sight, as we have to consider the ecologically-correct prescribed burning regime for each of the main vegetation biomes within the Garden Route region, based on research results as collected over the past three to four decades.

For the purpose of the Garden Route region, I have differentiated between (i) fynbos shrubland (sub-divided between Mountain Fynbos, Renosterveld and Strandveld), (ii) industrial timber plantations (sub-divided between the plantations found along the mountain foothills and plantations established on the plateau) and (iii) Afromontane forests (sub-divided between the mature (high) forests as well as plateau scrub forest. This structure will also form the basis for the regional fuel model base to be developed for this region, with in some cases main species and age groups to be considered in fynbos shrubland and timber plantations.

5.1 Fynbos

Across the three main fynbos types in this region (Mountain Fynbos, Renosterveld and Strandveld) the following main age groups have been identified with main characteristics provided:

<u>Immediate postfire phase:</u>
This represents the first twelve months after fire, when the successful germination of seed and establishment of plants occurs, apparently from seed stored in parent plants prior to fire or in the soil. On the whole it does not appear that immigration of species is an important process of post-fire succession. Once established, young plants apparently suffer relatively little mortality (Martin 1966).

Youth phase (up to 4- to 5-yr):
Fynbos is quickly dominated by restionaceous and graninoid plants and sprouting shrubs, the remaining species attaining reproductive majority. The vegetation becomes flammable at about 4 yr.

Transitional phase (up to about 10 yr):
Most plant species attain reproductive maturity in this phase. Tall shrubs emerge from the canopy and adopt the ascending branch habit.

Mature phase (up to 30 yr):
Tall shrubs attain maximum height and full, rounded form, with maximum flowering activity. Seeding low shrubs begin to die, litter accumulates more rapidly and lower herbaceous strata are reduced in importance and negligible establishment of germinules occurs.

Senescent phase:
Mortality among seed-regenerating shrubs accelerates, foliage on survivors is reduced to tufts at tips of branches, and crowns become open. With the opening of the canopy, some seed regeneration may occur. Litter and dead shoots continue to accumulate.

Post-fire succession in most fynbos communities is notable for rapid initial recovery, owing mainly to perennial graminoid herbs and sprouting shrubs. Although germination after fire may be delayed in some instances, species richness in the plant community is at a maximum in the immediate post-fire phase and after (Kruger and Bigalke, 1984).

EFFECTS OF FIRE INTENSITY
Fire intensity as a factor influencing vegetation structure and dynamics could perhaps be viewed as follows: High intensities will have several important effects and abnormally high mortality among sprouting plants is likely. Trollope (1973) reports reduced grass basal cover due to "hot" fires, to the advantage of species. Also, germination of hard-seeded species will be favoured. Growth of all plants will be favoured by the ash-bed effect, but the net consequence of abnormally high intensities would be a change in composition, towards an increased woody plant component, especially seeding shrubs. Abnormally low intensities will apparently have an opposite effect, favouring graminoid and restioid herbs over woody elements. The effect of average intensity fire would be intermediate between these two extremes (Kruger and Bigalke, 1984)

De Ronde (1990) found that the higher the fire intensity of a timber plantation system, the higher would be the loss of macro-nutrients and nutrient availability decreases in the top soil. Subsequently, increases in fire intensity with maximum consumption of above-ground forest or shrub floor material and incorporated seedbeds will be detrimental for the system.

EFFECTS OF FIRE FREQUENCY

The gross effects of fire frequency are usually the most easily seen and most frequently commented upon of regime effects. The marked contrast between vegetation at Jonkershoek subject to 6-yr burning and that subject to fires once in about 15 to 20 yr has been reported by van Wilgen 1981, 1982). This is then also accepted as the norm for Mountain Fynbos, but increased to more than 25 yr fire frequency in slower-growing Renosterveld.

In Strandveld variation from this frequency is normally dependent on the degree of weed infestation, such as with *A. Cyclops*, the denser and more dominant the weed, the lesser the chance for normal prescribed burning application and subsequent eradication of the weed without normal fynbos maintenance of biodiversity (own observations)

Extreme frequencies may have non reversible effects on vegetation and result in new stable vegetation equilibria. For example, high frequencies may cause local extinction as is the case of *Erica* spp. and *Cliffortia* spp. in the Amatole Mountains (Downing *et al.,* 1978). In most cases it seems that variations in frequency will instead govern the relative abundance of different plant forms (Kruger and Bigalke, 1984).

EFFECTS OF FIRE SEASONS

The influence of season of burn is related to the seasonality of growth and reproduction in species of any given plant community. Phenology of fynbos communities is complex (Kruger, 1981) so that a uniform response among species in any given community is not to be expected. Nevertheless, in the winter rainfall region of the Western Cape, late summer or autumn (February to April) are considered to be "natural" there in the fynbos environment, so that vegetation subject to burns in this season should remain relatively stable (Kruger and Bigalke, 1984).

The biggest problem with prescribed fire application in the winter rainfall area, is that this then fall in the driest season with common strong south-easterly winds. I would thus like to recommend extension of this burning period starting in November and extending this period into May, the latter depending on the actual start of the rainy season (own experience in the region).

In the Garden Route region optimum seasonality appears to be best somewhere between November and March, thus providing the fire managers there with better selection of burning dates in this "constant rainfall climate" (own observation). This also appears to be the case east of the Garden Route region, including in the Tsitsikamma and Amatolas, which are situated in the summer rainfall area.

From the above notes – based on decades of research – it will be clear that fire exclusion in fynbos shrubland will have a serious detrimental effect as this will only cause serious disruption of the maintenance of biodiversity, when wildfire burns fynbos during the senescent phase when adverse fire effects will most likely be the end result. In contrast optimum fire intensities, required frequencies as well as season of burning guidelines have been provided to assist fire managers in control of fynbos-covered land can use the well-researched guidelines to ensure safe burning in the shrubland to ensure optimum maintenance of biodiversity.

5.2 Industrial timber plantations

Found along the Outeniqua Mountain foothills as well as on the Southern Cape plateau, these commercial forestry plantations are nowhere dominating as the fynbos vegetation does. However, because these (mainly Pine) plantations can be incorporated with prescribed burning along strategic fire prevention lines (buffer zones) and they form a vital local forestry-related industry, the correct fire management regime within these stands can be of extreme importance for successful integrated fire prevention at regional level.

While the non-performing species (such as *Pimus pinaster*) where phased-out and replaced with mainly *Pinus elliottii*, *Pinus radiata* was still the preferred species, growing on the sandy dune soils of the plateau, as well as on the better sites of the foothills, and both form the backbone of the region's forestry operations. Both species originate from Northern American sites of origin, and both require fire to maintain their biological existence there.

Subsequently, both *Pinus* species were established on original fynbos sites, which we already identified as being fire-dependent in their maintenance of biodiversity, and it is thus clear that these commercial forestry stands also require fire at times to maintain their ecological existence (de Ronde, 1988; 1992). The use of prescribed burning has been well-researched in the region from 1978 until the early 21st century, information which was collected from more than 25 experimental prescribed burning experiments in both the Southern Cape as well as the Tsitsikamma forest regions.

5.3 Afromontane forests

In general it can be said that the forest communities do not require fire to maintain biodiversity, but that these forests are vulnerable against fire damage from adjoining vegetation types, such as along the Garden Route fire damage from fynbos or from industrial plantations, growing on sites adjoining forest edges directly. Where forest edges have been damaged by wildfires, pioneer species normally regenerate in abundance, but these also need to be protected against wildfires, by an approximate 50 m wide "regenerated-development" zone, protected by a cleared fire break to allow unrestricted regeneration and resprouting.

Within the Outeniqua Mountains, some forests are surviving because they grow in naturally-protective topographical features in the landscape. However, others are directly in the path of Bergwind fires, and are normally systematically reduced by wildfires until completely burned out and regenerated to fynbos.

On the plateau, some forests are well protected, while others are bordering fynbos land or other land-use, such as forestry plantations or agricultural land. The first consideration should always be to incorporate vulnerable forest patches within region buffer zones to (i) provide unburn able forest for the buffers and/or (ii) let the protective fuel management measures incorporate simultaneously fire protection for vulnerable forest edges.

Scrub forest should be assessed whether this requires fire protection or not, and if portions should be treated with prescribed fire to reduce levels of dangerous fuel accumulation.

Non-exploited forests cannot burn inside mature forest stands with dense (closed) crown canopies, but where forest edges were damaged by timber exploitation on adjoining land, and/or the forest edge was damaged by a wildfire, added fire protection will probably have to be created to avoid future wildfire exposure. Here it is thus a matter of the Afromontane forests not requiring prescribed fire for the maintenance of biodiversity, but rather to determine what fire protection specific forests require (own observations).

To summarise:

(a) Comparisons between fire exclusion and selective controlled burning have been made in this Chapter by the main vegetation types/biomes of this region, with the emphasis on fire ecological requirements, to prove the need for each biome by region.

(b) It was only in the case of the Afromontane forests in the Garden Route region that fire was identified for a different role because here no need was found for using fire within this vegetation type. However, there is a positive role fire plays here in using the tool for fire protection purposes on forest margins.

(c) In all biomes/vegetation types within the Garden Route region – except Afromontane forests – there is evidence that fire is important to maintain biodiversity and that fire exclusion is detrimental for this vegetation base.

CHAPTER VI

RESULTS: FIRE ECOLOGY IN FYNBOS

Fynbos is not only the smallest, but also the richest, plant kingdom of the world in terms of number of species! Subsequently, the Cape regions of South Africa – where it grows in its natural environment – has been attracting biologists from all around the globe, long before settlers arrived here in significant numbers. Its maintenance of biodiversity is thus high on the agenda of this unique plant kingdom, and with this the role of fire ecology.

No wonder fire ecology has been well researched over the past 5 – 6 decades and its fire-requirements have been formulated in a range of scientific publications. This Chapter should thus be seen as a summary of research results of this subject in a practical way.

6.1 Fynbos

Fynbos is a vernacular term for fine-leaved shrubs a vegetation dominated by evergreen shrubs. These include small-leaved ericoid shrubs, and many species of Ericaceae, but also many shrubs in other families, including several endemic families such as Bruniaceae and Peneacae. Mixed with the ericoid shrubs are taller proteoid shrubs, dominated by members of the Proteaceae. The most distinctive of features of fynbos is, however, the universal presence of Restionaceae. These are wiry, evergreen grass-like plants. They are common, often dominant, elements of the fynbos understorey.

Fynbos shows remarkably little structural variation, given the wide range of moisture and soil conditions under which it is found. This is particular surprising because of the very high species diversity for which the Cape is famous The fynbos biome contains some 7300 species of which about 80% are endemic (found nowhere else in the world). The uniqueness of the flora is a major consideration in its management (Bond *et al.*, 2004).

6.2 Renosterveld

Renosterveld was once an important component of the fynbos biome, occupying ca 20 000 km^2 on the more clay-rich soils of the coastal forelands and inland valleys. It is common to find abrupt transitions from fynbos on the sandy soils of quartzite mountain ranges to clay rich soils derived from shales on the lower slopes.

Renosterveld has been radically transformed by agriculture since much of its former area was suitable for farming. Only small pockets remain in the extensive wheatlands of the north-western and southern coastal forelands, with more extensive areas in the steeper terrain on mountain foothills. Though it can have a somewhat drab, monotonous aspect, especially in mid-summer, Renosterveld is rich in geophytes. After a burn, these can produce a spectacular flowering display (Bond *et al.*, 2004).

6.3 Strandveld

Strandveld differs from Mountain Fynbos and Renosterveld in that the dominant elements are fire-avoiding. There are broad-leaved evergreen shrubs and small trees forming patches of thickets of shrub forests. The broad-leaved thickets intermingles with elements of fynbos and Renosterveld. Where serious infested *A. Cyclops* is dominating the vegetation in Strandveld, a fire-dependent component will be added to such communities, which will be harmful to regeneration of fynbos species after a wildfire (own observations (see Photograph 7).

6.4 Role of fire in fynbos

The fire ecology of fynbos has been well studied especially from the 1980's, yet there are still surprises and new discoveries to be made. In the early years of the 20th century, fire was seen as a damaging influence on the biota by most influential biologists of the time. This view began changing by the 1950's and there is now widespread recognition that a great many fynbos plant species require fire to complete their life cycles. Some examples of research findings re the relationship of fynbos and fire can be provided as follows:

- Burning triggers different stages in plant life cycles, including flowering, seed dispersal and seed generation in fire-dependent plants. Perennial grasses and herbs, including orchids, lilies and other bulb plants, flower prolifically after they have been burnt, often as a facultative response to higher light, water and nutrient availability. The seed of fire-flowering species typically germinate readily. However, seeds only become available after a burn, so that population growth is episodic by fire.

- Burning stimulates seed release from species with serotinous structures, which store seeds on the plant for years between fires. Serotiny is common in shrubs and small trees among both Conifers (*Widdringtonia*) and diverse groups of flowering plants in fynbos. Many species in the Proteaceae are serotinous (species of *Protea*, *Leucadendron* and *Aulax*) and often dominate fynbos stands.

- Many species of fynbos plants accumulate seeds in dormant seedbanks in the soil. Most have specialised seed germination cues linked to fire. Heat stimulated seed germination is common in many legumes (e.g. *Aspalathus* spp.) and in other groups with hard seed coats. Thick seed coats prevent imbibitions of water, until cracked by the heat of a fire. Smoke-stimulated seed germination has recently been reported for many species of fynbos, shrubs and herbs (Bond *et al.*, 2004).

- Species with fire-stimulated flowering, seed release or seed germination require fire for their populations to grow. Fynbos also includes species with no fire-related recruitment cue and these species are able to expand their populations in the absence of burning. Broad-leaved shrubs and trees of forest affinities are prominent among this category, and population growth is favoured by long periods without burning.

- Vegetative features of plants affect tolerance to burning. Thick bark and the ability to resprout enable many plants to survive burning. Neither feature is necessarily a fire adaptation. Sprouting is a common fire survival mechanism, either from the rootstock or from branches above the ground. Paradoxically, many fynbos shrubs and restios cannot resprout and are killed by fire. These non-sprouting plants often have higher seed production and higher seedling growth than related sprouting species. Non-sprouting shrubs often dominate fynbos stands and require fire to stimulate recruitment of seedlings.

- The Renosterveld shrub *Elytropappus rhinocerotis,* has variable sprouting behaviour across its wide geographic range, sprouting after some fires (some geographic areas) but not in others. Seedlings emerge in the first year after a burn, but the species can also invade open patches in the absence of the Renosterveld, which is now highly fragmented by agricultural activity, and burning is actively discouraged in many of the remnants because of the risk to adjacent agricultural land.

- The response of Strandveld to burning is even less understood than Renosterveld. The dominant broad-leaved shrubs all sprout after burning, but their seedlings are fire avoiders. Frequent intense fire in Strandveld are likely to promote the fynbos elements at the expense of the broadleaf shrubs. Strandveld is the least likely of the biome components to contain species with an obligate dependence on fire.

To summarise:

(a) The role of fire in fynbos shrubland has been well researched and defined for optimum fire frequency, required season of burn as well as optimum fire intensity, within the Mountain Fynbos sub-biome, but less within Renosterveld and Strandveld as a result of lesser importance.

(b) For related shrublands in Mediterranean Zone-biomes, extrapolation will be possible, provided any fire-ecological research within shrublands in other regions have been checked for results and variation between the geographic relationships.

CHAPTER VII

RESEARCH RESULTS: PROTECTING INDIGENOUS FORESTS AGAINST WILDFIRES

Afromontane forests are rare in Southern Africa, but along the Garden Route these natural forests form a relatively-high percentage of landscape cover. Even when Industrial plantations were not yet established in the region, pioneer forest managers have attempted to protect this vulnerable timber source, and cutting of timber within these forests was stopped by Law during the 1930's.

It was soon discovered that these forests were susceptible to fire damage and that some form of fire exclusion would be needed to maintain its biodiversity. Under this Chapter, fire protection options are considered for practical application at regional level.

The effects of fire on biodiversity in forests have three different components: (a) fire's effect on the persistence and location pattern of forests, (b) maintenance of forest ecotones and (c) rejuvenation of forest dynamics when fires do enter forests.

7.1 Forest persistence in "Wind Shadow" areas

Geldenhuys (1994) showed that environmental factors (rainfall and substrate) determine the potential limits of forest distribution, but that actual forest location pattern is determined by the fire pattern. This in turn is determined by the interaction between prevailing winds during dry periods and terrain physiography in the Southern Cape of South Africa, like in many other areas, forests persisted in topographic shadow areas of the gusty, hot, desiccating north-westerly Föhn-like Bergwinds, which are common during autumn and winter.

Fires (during Bergwinds) would most likely follow the flow direction of the wind and would destroy forests along that route. Such fires would burn with higher frequency in zones in the landscape where forest is currently absent (covered in fynbos and plantations), and would cause calm conditions and a lower frequency of fire in localities where the forests have survived (Geldenhuys *et al.*, 2004). Forests can therefore recover from episodes of extreme fires, but disappear from areas where fires occur at higher frequencies.

Photograph 9. N2 national road following its route through the Storms River indigenous forest. Note "hard" forest edges on both sides of this road (Picture taken by C. de Ronde).

7.2 Maintenance of forest ecotones

The large ratio of forest margin to forest area, accentuates the importance of forest margins in forest survival. Forest margins or edges have a more or less fixed position in the landscape as a result of the wind-determined fire patterns. The forest edge can be hard where there is an abrupt change in forest structure (growth form compositions) of these fire effects are that the mountain forests are generally small and more frequently disturbed, whereas the coastal platform forests are larger and less frequently disturbed (Geldenhuys *et al.*, 2004).

Plainly, post fire changes in structure and dynamics in forests and forest margin communities are, to a great extent, determined by the adaptive responses of forest and forest margin plants to fire. The typical abrupt margins of many forests, whose surrounds are subjected to regular fires, substantiate this (Granger, 1984).

The shape and condition of the ecotone between the forest and adjacent fire-adapted vegetation will determine the degree to which the forest will be damaged during fire from adjacent vegetation. A soft gradual edge, typically dome-shaped, will cause the wind-driven fire to brush over the forest edge. Human-caused forest edges are usually hard, resulting from forest clearing and regular controlled fires. A fire would cause more severe damage to a forest with a hard edge, particularly with accumulated debris (after windfalls and tree felling in adjacent timber plantation stands) and dry weather conditions (Geldenhuys *et al.*, 2004).

7.3 Forest dynamics in response to fires inside forests

A study has shown that charcoal in litter and feeder root zone of the forest floor can be found in about 30% of the Southern Cape forests, South Africa (Geldenhuys, 1993). No study has yet been made of the charcoal in terms of species composition and age. Such charcoal may originate from fires burning from the outside into the forest understorey or from spot fires entering the forest from wildfires on the forest margin or from honey hunters or from lighting (e.g. Geldenhuys *et al*., 1994).

The response to such fires is a rejuvenation of the forest through the development of forest pioneer communities either from soil-stored long-living legume seeds (Geldenhuys, 1993) or other herbaceous and woody species, or from dormant soil-stored fern rhizomes (Geldenhuys, *et al.*, 1994).

To summarise:

(a) Research findings re the ecological role of fire indicate that forest margins (edges) are vulnerable for fire damage, particularly where hazardous fuels are found close and up to the main forests. Subsequently, the role of fire in adjoining vegetation type should be checked for fire-use, for forest protection purposes.

(b) The role of fire-use in scrub forests should be carefully considered in relation to individual forest development from fynbos to forests, and related fire protection or use. Regional fire prevention buffer zones and their construction could play a vital role in this decision-making process.

CHAPTER VIII

RESEARCH RESULTS: FIRE-USE IN TIMBER PLANTATIONS

The role of these timber plantations in the Garden Route region was - from its early beginnings - to replace the indigenous forests as an industrial timber source and thus presented a vital role in this area, during the early 1900 decades. From the mid-1900's until today, this role of mainly Pine plantations was reduced as more timber volumes became available from later tree establishments in the summer rainfall forest regions, but locally the role of this industrial timber source is still important and should not be under-estimated.

Until the late 1970's the role of fire inside even-aged Pine stands was completely ignored and "total fire exclusion" was accepted as the general norm in South Africa. Research to investigate the opposite – that there is a fire-related role to play in side even-aged Pine stands – was investigated with field experimentation in the Southern Cape as well as the Tsitsikamma forest regions and by 1978 the first experimental fire-applications were attempted under Pine tree canopies in both forest regions. The results of this programme have been summarised in this Chapter.

8.1 Fire effects on plantation forest floor vegetation

It is only at the early stage of even-aged industrial plantations that the vegetation relates mostly to its original, natural, source (such as to fynbos in the western and southern Cape forest regions). Once tree crown canopies are closed and in consecutive rotations, the original vegetation may re-appear temporarily after clear felling of the tree crop and timber exploitation, only to be suppressed again when the next tree rotation develops a closed crown canopy.

Often there is also an added "weed" component present, which may consist of species of previous planted commercial tree species, such as *Acacia mearnsii* or *Eucalyptus* species, or other exotic invaders such as other *Acacia* spp., or indigenous invaders such as *Gleichenia polupodioides* (Kyster Fern). It is clear that these variations in the plant communities, during the different stages of development of the plantations, will influence fire effects significantly depending on the type of plant community that develops, together with the type and age of tree crop (thus here *P. elliottii* and *P. radiata*) and climatic conditions.

Application of low intensity fire under the dormant overstorey can also facilitate micro-climatic changes in decomposition dynamics, and thus indirectly contribute to improved forest floor vegetation regeneration of both the natural and exotic components. In stands with a poor litter breakdown as a result of lack of fungal activities within forest floor layers, litter loading may accumulate and even a low intensity fire can increase pH and nutrient availability significantly. This will improve fungal activities and improve litter decomposition and can also lead to increased regeneration and stimulation of natural beneficial and exotic detrimental seed stores (de Ronde, 1992).

8.2 Fire effects on fungi and soil micro-organisms

Some litter accumulation problems have been recorded inside Pine plantations in Southern Africa, as a result of (either) a lack of fungal activity or the absence of key micro-organisms responsible for humus (duff) breakdown (De Ronde 1984; De Ronde 1992; Morris 1986; Schutz *et al.*, 1983).

Photograph 10. Example of ash-bed effect in mature *Pinus elliottii* having a sterile needle mat layer on top of the forest floor, changing after a light intensity prescribed burning application to a thick grassland cover favourable for grazing (Picture taken by C. de Ronde).

In the Cape Forest regions of South Africa humus (or duff) layers fail to be incorporated as organic matter in the soil because of the apparent lack of capabilities of fungi and soil micro-organisms to fulfil this task on clayey duplex soils in *Pinus elloittii* stands of the Tsitsikamma region of South Africa. The abundance of fungi decreased significantly with an increase of humus thickness, indicating that a lack of fungal activity is one of the causes of humus accumulation (De Ronde, 1992). As the problem is particularly related to soil acidity, it is possible that prescribed fire (and subsequent pH increases) can improve decomposition on these soils, although this aspect has not been properly researched (De Ronde, 1992).

8.3 Fire effects on trees

The following types of fire damage can occur:

<u>Cambium damage:</u>

Chandler *et al*., (1983) have cited the characteristics of bark, which are important in insulating the cambium layers as follows:

- Bark thickness
- Density of bark
- Thermal conductivity (rate of penetration of temperature)
- Moisture content
- Bark thermal absorptivity (the capacity of the bark to absorp heat rather than to transfer it to cambium layers)
- Combustion properties

Injury to tree cambium normally occurs on the leeward side of trees (i.e. the opposite side of the tree stem relative to the advancing fire front) just above ground level.

Photograph 11. Wildfire damage categories in Pine plantations. “1” = Crown fire damage, “2” = Complete crown scorch, “3” = Crowns partly scorched (Unknown picture source).

Crown scorch:
In most cases tree mortality is generally related to crown damage rather than to bole damage (Cooper and Altobellis, 1969; De Ronde 1983; Kayll, 1963; Wade and Ward, 1975). The susceptibility of certain species to crown scorch may differ within a genus, e.g. the needles of some *Pinus* species (such as *Pinus patula* and *Pinus radiata*) are more susceptible to crown scorch by a given fire temperature than other species such as *Pinus elliottii.*

Crown scorch can be described as the mortality of the leaves caused by the scorch of the surface fire, which is then displayed in the form of crown discolouration without crown consumption. This discolouration will be visible immediately after the fire, and leaves will drop from the trees some weeks later.

Crown fire:
This occurs when a surface fire is carried into the crowns of trees, resulting in the complete consumption of the leaves (De Ronde, 1990). The effect of total crown consumption is drastic and recovery is rare, although scattered recovery of some trees has been observed after resprouting has occurred in the crowns of some trees (De Ronde, 2001). *Pinus* trees exposed to crown fires will experience high mortality and standing timber will dry and degrade rapidly (De Ronde *et al.,* 1986).

Root damage:
Roots have a thin cortical covering and if found near the soil surface, are easily damaged by fire. Shallow rooted species are frequently damaged by ground fire as a result of injury to roots, even though the stem and crown are nor effected (De Ronde *et al.*, 1986). The depth and character of the forest floor (organic layer) may largely control damage inflicted by surface fires to roots, especially of the more shallow rooted trees (Davis, 1959).

Secondary damage:
Where damage in the form of severe crown scorch and/or cambium damage has occurred to the trees, some resprouting after a fire may give the impression that the trees are recovering. However, within months, the new leaf development can die back and mortality occurs (De Ronde, 1983).

In the case of *Pinus* tree species, the cause of mortality may be due to the pathogen *Rhizina undulata*, which attacks the remaining living roots where the cambium was not damaged. This type of secondary damage is particularly common where the humus has been consumed by fire (Baylis *et al.*, 1986). The bark beetle *Ips erosus* may also cause mortality where trees have been severely injured by fire (Baylis *et al.*, 1986; de Ronde *et al.*, 2004).

To summarise:

(a) Research findings are clear about the fire-ecological requirements within Pine plantations in the Garden Route region because (i) the role of fire in their original habitat and (ii) these trees were mainly established in fynbos vegetation where the need for fire-use was already established.

(b) Research results from the South African research program have already been extrapolated to some individual countries, because the role of fire within Pine stands has been well established at a global level, particularly in the Mediterranean Zone-biome.

CHAPTER IX

ASSESSING WILDFIRE DAMAGE AND ITS IMPACT ON THE REGION

Mega-wildfires do not only cause serious damage to the timber source of industrial plantations, but can disrupt the forestry industry as a whole, by causing damage to the sustainable timber yields, necessary to maintain this vital activity.

It is rather surprising that so little is known by forest managers about the dynamics of fire damage to trees in general that even a question such as "when will a tree die?" cannot be answered by most. Subsequently, some managers "panic" after a wildfire burned through their plantation, and then start to cut the largest/oldest trees first after a fire, which many times includes trees that actual survived from the fire and could be maintained and remain growing as a timber source, thus cushioning the wildfire impact on sustainable timber yields.

It is important that the damage to trees (timber crop) and soil (tree growth media) is assessed within weeks after a wildfire, and that the status of degrade or recovery is monitored regularly thereafter. After each wildfire, the impact of an uncontrolled fire can be classified as follows:

Light impact:
It is mostly crown scorch that is experienced in this class, and crown fire consumption is rare or absent. A partly consumed forest floor is another characteristic of this damage class, and there is normally no direct exposure of soil surfaces to hot fire temperatures, with no yellow or white soil discolouration present after the fire.

Medium impact:
Both crown fire consumption and various degrees of crown scorch have occurred and most of the forest floor biomass has been consumed by fire. Soil surface exposure to hot fire temperatures may be more common than in the case of a light impact fire, but is still only found in less than 25% of the area affected by the wildfire.

Serious impact:
Crown fire consumption by crown fires and so-called "crown fire streets" are common. Where crown scorch occurs, this will dominantly be in the form of complete scorch of crown volumes. All forest floor material was consumed by the fire, and exposure to hot fire temperatures has resulted in common soil surface fire discolouration, and soil repellency.

Photograph 12. Site where extremely-high fire temperatures were experienced with a high residence time, where a *Pinus radiata* crown fire eventually spread outside the plantation and at the stand edge. Where the light coloured soil is visible at the stand edge (in the picture between the stand edge and the plantation road) the crown fire changed abruptly into a high intensity surface fire, and the topsoil was visibly exposed to serious wildfire effects on nutrients at this site (Picture taken by C. de Ronde).

<u>Assessment of damage to trees:</u>
Individual trees and tree stands can be assessed for fire damage as follows:

- *Inspecting for cambium damage*
  Injuries to the cambium and phloem are not easy to detect in external inspection and the need for a non-destructive method for detecting the presence of dead cells within the cambium and phloem tissues, has been identified as early as during the 1960's as an early detection method (Curtin, 1966). Once cambium damage is suspected, it can be detected by inspecting the bark just above the ground line, on the leeward side of trees (Fahnestock and Harvey, 1964). Cambium damage can be identified by discolouration (Cremer, 1962), by the use of stains such as tetrazolium chloride (1% solution in water) (Kayll, 1963) and other more sophisticated methods, apart from direct field inspection of the tissue for discolouration (De Ronde *et al.*, 1986).

- *Marking and mapping affected crown fire damage areas*
  As the crown needles of trees exposed to crown fires have been completely consumed by fire, almost all trees falling in this category will die, and degrade of timber will be relatively fast in these areas compared to trees that experienced only crown scorch. It is important to mark these areas clearly in the field with paint spots on tree stems, and

to map crown fire areas where these commonly occur, as these trees will have to be exploited soonest after the fire.

- *Clear felling and monitoring degree of crown scorch*
  It is important to divide this type of fire damage in two categories, namely (a) total crown scorch and (b) partial crown scorch. In the case of the latter most trees normally survive, unless they have been exposed to secondary damage. In the case of total crown scorch, trees such as *Pinus radiata, Pinus patula* and *Acacia* spp. will probably die (apart from stump resprouting in the case of the latter), while species such as *Pinus elliottii*, Pinus *taeda* and *Eucalyptus* spp. can sometimes resprout readily during certain seasons (De Ronde *et al.*, 1986)

- *Inspecting for root damage*
  Where shallow root systems occur, exposed roots must be inspected for damage, as secondary damage may occur at a later stage caused by *Rhizina undulata* (De Ronde *et al.*, 1986).

- *Regular inspection for Rhizina undulata fruiting bodies*
  In case where the soil surface was completely exposed to fire, *Rhizina undulata* damage is possible, and stands should be inspected within weeks after a wildfire has occurred in *Pinus* plantations, and at monthly intervals thereafter. Where a needle mat was formed from fallen (scorched) pine needles, these continuous layers should be lifter up to inspect the soil surface underneath for fruiting bodies formed by the pathogen. Old tree stump channels should also be expected for signs of *Rhizina* on top of the soil surface.

  Rhizina may also attack damaged trees so that they die back steadily, and this can be observed by inspecting surviving tree crown needles for signs of dying-back and yellowing. This kind of damage may only be noticed months after the fire, but can be very serious and common. Re-establishment of the trees should then also be postponed until the *Rhizina* fruiting bodies have dried out (Linquist, 1984; De Ronde *et al.*, 1986). The pathogen may also appear in areas where slash was burned, in which case re-establishment will have to be postponed for a few months until it has been observed that the fruiting bodies are dying back and drying out (De Ronde *et al.*, 2004).

<u>Assessing tree re-establishment potential:</u>
The more serious the wildfire impact, the more problems can be expected with tree replanting. In the case of a wildfire that occurred on a nutrient-poor site, steps will have to be taken to overcome nutrient deficiencies, and soil sampling to determine the nutrient status of the topsoil (a few months after the wildfire) is recommended. After serious impact fires, more problems can also be expected as a result of physical damage to soil properties and these sites are also more susceptible to *Rhizina undulata* infestation.

To summarise:

(a) This Chapter provides a package to optimise timber exploitation after having been exposed to a wildfire, as well as action with re-establishment, as and where required.

(b) The main aim with this Chapter will be to optimise timber recovery after a wildfire and to assess which trees recovered after the fire and which died (mortality). Linked to the latter will then also be (i) time available for exploitation, (ii) survival identification and (iii) monitoring for secondary damage probability.

CHAPTER X

THE IMPACT OF THE 2017/18 GARDEN ROUTE WILDFIRES

No doubt that these two serious wildfires shook this region more than anything else did over the past number of decades. However, a serious assessment of the reasons for these wildfires, and sustainable solutions, still have to be considered, let alone approval for drastic fire prevention action programmes.

It has now been a bit longer than one year after the 2018 wildfires burned over more than 100 000 ha. This is not the end of these fire disasters, but only the beginning, as climate change is now with us to stay......

10.1 The 2017 Knysna wildfire

Photograph 13. A picture of the 2017 Knysna fire in progress, as seen from "Thesen's Island".The fire glow visible is from the fire burning in the resident area of Knysna (Courtesy Harja Raubenheimer and Kevin Reid).

The first fire started inside *Pinus radiata* plantations, in the Ruigtevlei area, west of Knysna, north of Sedgefield and of the N2 national road. When spreading, the fire front was driven by a north-westerly Bergwind, in a general south-easterly direction, just north of and parallel to the N2 national road, through about 10km of these plantation stands. "One finger" of the fire then spread across the N2 into private farm land (actually burning over a railway bridge over the N2 national road, covered with dense weeds as a result of neglected vegetation management), as well as into the Goukamma Nature Reserve managed by the "CapeNature" conservation organisation, operated by the Western Cape Provincial authorities.

The fire subsequently spotted from that area across the Goukamma river, and then spread in the direction of Buffelsbaai (Buffalo Bay), a community which was fortunately untouched by the fire, because of its general fuel-free nature of the environment in and around this township.

The fire then spread from there north of Buffelsbaai, through the Brenton-on-sea township, and then into the Featherbed Nature Reserve and the fire then also spread close to the Belvedere township on its left flank, where it was stopped by the waters from the Knysna Lagoon. How the fire eventually ended up north and east of Knysna is not at all clear to me, though the fire could have spread here from a section of the fire continuing to spread north of the N2 national road. Here the fire burned through the Rheenendal community and the surrounding land, and then also crossed the Knysna River, just east of this.

Photograph 14. View of the Knysna fire area after the fire, from its origin, through Knysna, to the Harkerville plantation on the far right of the image (Courtesy CSIR/AFIS).

The areas situated east (on the right) of the image, not shown on the above Photograph, include Plettenberg Bay and the Tsitsikamma area. Some homesteads in Plettenberg Bay also burned out, while some Pine plantation areas were also lost on the Tsitsikamma plateau, which was somehow also exposed to the fire(s) but with separate fire origin(s). Although the original (main) fire spotted across the Knysna Heads, there is no evidence that any significant fire damage was indirectly caused by this fire’s spotting action, and subsequently the forming of the fire scar east of the Knysna river mouth was most probably caused by at least one additional fire origin.

When the fire entered Kruisfontein plantation, the head fire continued spreading in a general south-easterly direction, until it was stopped in its path by the indigenous forest, east of this plantation. It also burned into the western portion of the Harkerville plantation (now part of the Kruisfontein plantation), with evidence that at Harkerville the fire started at Kranzhoek, either as a separate ignition point, or as a “spotting landing site” from the Kruisfontein fire. I have no evidence of either scenario. However, we do know that this fire then subsequently burned through Harkerville plantation and beyond, as far as into the western section of Plettenberg Bay, where some homesteads also burned out, and where the fire eventually stopped spreading further (Photograph 14).

10.2 The 2018 Outeniqua wildfire

While the Knysna fire burned over more than 30 000ha, the Outeniqua fire burns exceeded 100 000ha in total area. Note that most of these fires were still spreading at the time the satellite image was taken (Photograph 15), mostly though within the rough mountainous terrain of the Outeniqua mountain range. The fire also spread at lower altitude, into the mountain foot slopes with mostly southerly aspects. How many independent wildfires made up the total wildfire area burned over is not known.

Photograph 15 Outeniqua wildfire image with fire boundaries drawn in, while burning was still in progress. Note that there are still separate fires burning (see red fire perimeters) loose from the main fire (orange fire perimeters). Main roads through the region are shown with white lines (unknown satellite image origin and fire perimeters artist).

Photograph 15 shows clearly how the Garden Route was exposed to multiple fires, with the first fire affecting the region starting near the small community of “Herold”, situated north of the Outeniqua Mountain range. There was in fact an earlier fire ignition a few days earlier near Riversdale, near the small community of “Vermaaklikheid” which cause significant damage, but never became part of the fire(s) in the Outeniqua Maountains. I have not investigated these multiple fire events, and will subsequently not be in a position to comment on individual fires, which are however clearly indicated on Photograph 15.

Although most of the main fire spread through the fynbos shrubland dominating the mountains along the Garden Route, most damage was caused where the fires spread into the mountain foothills south of the Outeniquas, where the fynbos shrubland “touched” on civilization (along the clear interface between the mountain shrubland, and land changed by man as a result of Pine plantation establishment and agricultural activities).

The most prominent vegetation before the fire where these fires burned through, was senescent fynbos vegetation, with age groups far beyond the optimum fire-required age of 12 to 20 years, even exceeding 50 years of age on some sites. No wonder these multiple fires were unstoppable until the whole of the Outeniqua Mountain range was basically burned out.

No doubt this multiple wildfire event will have a marked effect on future fynbos management in these catchments, and I hope that the conservation managers will not fall into the same “fire exclusion trap” again, by simply failing to expose the region from so much needed fire-use. What is also a worrying aspect of these fires is that such a lot of fire ignitions were made, isolated from the main fire. It appears to me that the main fire “excited” some people to make their own counter fires “to attempt to stop the main fire?”

That the Outeniqua wildfire(s) did have a significant impact on the pre-fire vegetation cover, is a fact. To predict when and how the prescribed (preventative) fire has to be applied to the region, will need some selected fire simulation studies to be applied, to understand fire needs better and then subsequently to make projected prescribed fire meaningful in the future. How to link this to areas as yet not having been exposed to uncontrolled fire will require some accurate decision-making, to ensure that fuel reduction will be applied correctly in the future, and in time.

10.3 Mapping the way forward after the fires

The basis for a long-term, regional, fire prevention plan has to be developed soonest, to avoid future repetition of the recent wildfire disasters. However, that some bold action will be required in terms of prioritised prescribed burning to avoid a re-occurrence of the 2017 and 2018 wildfires, is a reality, which is not negotiable. The region simply cannot afford more of these disastrous wildfires, which will take at least a decade or two to heal from the “wounds” caused by this recent “double disaster”.

“Yes”, there will have to be an absence of fire-use of all areas burned over, and “yes”! We have to concentrate our fire prevention measures for the interim to be applied in areas which have not yet been exposed to the recent wildfires. This will be mostly west and east of the area burned over by the Knysna fires from 2017, and mostly south, where the 2018 Outeniqua fires burned.

Photograph 16. The Knysna fire burning in the Belvedere area. The fire intensity has here reached frightening levels, causing most residents of this township to be evacuated by means of boats across the Knysna lagoon (unknown picture source).

The managers involved in the longer-term regional fire prevention planning, will have the responsibility to create the basis for such a plan, which may in places have to exceed the guidelines provided by the Act (101 from 1998). However, if this means having to amend the Act 101 and/or other Acts, so be it! The recent wildfires have changed the rules for fire application, and the lawmakers will have to be flexible here as well, ***as climate change will make such action now more urgent than ever.***

Act 101 was formed after some intensive consultation at the time when it was written to replace the old Forest Act of 1984, and most of it is still applicable: Its “clever” broad guidelines will have to be included, which make deviation from ridged property boundary lines possible after consultation between the property-owners involved. Likewise, I would like to suggest that disaster management officers are used to create and publish at least the necessary approval for certain “emergency” fire prevention measures, to avoid future disasters. Such measures can later be used as a platform to create more permanent action to change Act 101 accordingly.

10.4 Working towards the longer-term solutions

First of all, we have to admit that the Garden Route fire protection system failed. The 2017 and 2018 wildfires just bridged these (supposed to be) effective protective lines in the landscape and this book will point out and quantify why this happened.

OK, so during the past few decades fire exclusion became a significant contributing factor in allowing the region's fire protection system to fail, but – even if these firebreaks and fuel reduction programmes were in place and up to date - I have come to the conclusion that the wildfires would still have damaged a significant percentage of the regions' land because these fire break systems were simply ineffective, when tested against what they were supposed to protect.

Foremost, the fire protection systems (from now on I will use a better description of this term, namely "fire prevention systems" or "buffer zones") were following external property boundaries "according to the Law", which tells property owners that they are responsible for such protection, disregarding the mention in Act 101 that such protective lines can be shifted by mutual agreement, to become more effective. This approach to fire prevention at regional level does not meet the critical reality of what is really required to make a difference to extreme wildfire effects.

Secondly, there is no concerted regional management plan to determine needs, co-ordinate the creation of regional protective lines in the landscape (regardless property boundaries) and then maintain such protective systems (fire prevention buffer zones and supportive fuel reduction measures) effectively so that regional fire prevention can be maintained at a sustainable level.

Some simply say "the Law is a stumbling block to achieve real goals", but I think this is not a viable excuse. According to my experience the Law (Act 101) can be bend to suit requirements and where there is room for improving some sections of the Act (and I am sure there are some). Then such changes must simply be drawn up and handed in for approval.

Once the above "stumbling blocks" have been sorted out (more about this issue later in this writing) and the "fire exclusion" problem has been corrected, then we can go ahead and construct a regional fire prevention plan that can make a difference to the regional fire hazard. I will provide more detail about the plan and how we can work towards these goals.

To summarise:

(a) The most serious shortcoming of the first fire - the "Knysna" fire - was its total exposure of the Urban Interface to this external wildfire threat, because on most urban plots old fynbos was allowed to grow right up to individual homesteads.

(b) The original "Knysna" fire started at Ruigtevlei, but other (unexplained) fires also added to the main wildfire damage result.

(c) The second fire was actually a combination of a number of fires, many burning in complete isolation, the total area burned over eventually exceeded 100 000 ha, while the original fire did not even have the potential to burn one quarter of this.

CHAPTER XI

VEGETATION RECOVERY AFTER FIRE AND EXOTIC WEED CONTROL REQUIREMENTS

Under this Chapter the emphasis will not only fall on the correct after-fire weed eradication procedures, but more on accurate quantification of species-specific weed problems.

The use of remote sensing is considered to be an important tool in quantifying specific weed problems by species, which can ensure that areas are not only accurately calculated, but that their sites are effectively mapped, which can be particularly cost-saving on difficult terrain (to determine optimum access routes and cost-effective eradication options.

11.1 The control of Alien woody weeds in fynbos

Accidental fires in untreated area may necessitate additional follow up operations, such as in *Hakea sericea.* Clearing operations cause changes to the fuel properties of the vegetation. Dead plant material adds to the fuel load and such loads are concentrated close to the ground. This poses new constrains on managers. Unnaturally high fuel loads lead to detrimental effects on the vegetation after fire, and these have to be prevented. For example, where fuel loads are high following clearing operations, it may be necessary to burn under moderate conditions to reduce impact of higher intensity fires (Richardson and van Wilgen, 1986). This further restricts the number of days available for burning, or forces managers to burn in spring, to complete programs.

Once areas have been cleared, re-infestation from nearby non-cleared areas, poses a problem. This is particularly the case for species which have good dispersal properties such as the wind-dispersed seeds of *Hakea* and *Pinus* species. The effective control of species on a landscape basis is therefore necessary, and can probably only be achieved through co-operation by neighbouring landowners, in combination with biological and mechanical control.(van Wilgen *et al.*, 1990).

11.2 Considering fire use in weed infested areas

The spread of alien invaders, such as *Acacia mearnsii* and *Acacia melanoxylon*, has also developed into a serious hazard in the Southern Cape and in the Tsitsikamma, particularly along the rivers running through the plateau into the Indian Ocean. The control of weed regeneration – particularly after exposure to wildfire – has been identified as a serious threat to the weed eradication process (De Ronde, pers. obs.). However, systematic cutting and poisoning of remaining stumps is still the best solution to the problem, although care must be taken to reduce slash fuels after cutting to manageable levels where possible. Follow-up pulling out of seedlings after fire application is also important.

Gleichenia polypodioides (Kystervaring) is not an exotic weed but an indigenous fern but its spread – particularly in poor performing Pine plantations – can be quite serious to its natural habitat (fynbos and indigenous forest). It only becomes a problem (particularly in fynbos) if fire is excluded from such areas for too long, when these layers will overgrow and suppress other vegetation. Timely fire application will solve the problem effectively, because the species does not re-appear for more than a decade if layers are consumed by fire right down to the soil surface (De Ronde, 1988).

With regard to combating *Pinus* spp in Mountain Fynbos, the latest situation in the Outeniqua Mountains is well in hand, and even the "exit areas" are getting massive attention lately. However, old "mother" trees will still have to be cut, particularly in remote areas, with follow-up removal (pulling out) of its fresh seedlings in time, with follow-up treatments.

11.3 Vegetation recovery after wildfire

In fynbos this process should be restricted to "hot-spots", where the soil surface was exposed to extreme fire temperatures for relatively long periods of time, which can be identified by total fuel consumption as well as soil surface discolouration (De Ronde *et al.*, 2004). Within such areas, the topsoil should be pitted or ploughed, with a light super phosphate dressing. Then selected fynbos species' seed (still on its "mother plant" branches), should be applied as a surface dressing.

In Industrial Pine plantations, the same should apply on discoloured soil surfaces (Photograph 12), but here such sites should be re-planted with Pine trees after having been provided with a "spot-placed" super phosphate dressing next to Pine stems of planted trees only (De Ronde, pers. obs.).

11.4 The use of Remote Sensing before and after wildfire events

One of the main issues after a wildfire is not only to determine the impact of a fire on a specific weed problem, but to quantify this in terms of area affected (hectare) mapped before and after such an event, using satellite images. The methodology for this has been described in detail under the publication Flasse *et al.*(2004).

From historical studies the main exotic weed problems in the Garden Route region have been described by weed species and then in which vegetation type the weed type occurs, by means of concentrating on the main vegetation biome in which a specific wildfire has been burning, to draw in the weed-covered area on a before-fire satellite image. The next step will then be to determine the new vegetation type base on the after-fire satellite image and to draw in these lines.

A typical demand for remote sensing input will be of the 2018 Garden Route wildfire, where we know its boundaries from satellite images, and we can get a set of images at say two-year plus after the fire, when the prominent new colour base can be determined. The vegetation type will in this case be prominently fynbos, making the mapping exercise a relatively simply event.

To summarise:

(a) After a wildfire it is important that the correct follow-up procedures are followed to ensure that eradication efforts are most effective. For a start, the type of weed problem, where it was effected by a wildfire, with areas quantified should be determined before weed eradication programs can commence.

(b) The use of remote sensing on satellite images before and after a wildfire has been recommended here to ensure more accurate quantification of specific weed problems.

CHAPTER XII

METHODS: FIRE HAZARD CLASSIFICATION, MAPPING AND USE

Fire hazard rating mapping (with or without fire risk adjustments) has been used intensively throughout the world, using a range of methods. All have been developed for specific use at regional level, which all have merits for specific regions.

I deviated from the basis of fire hazard calculation, by developing a region-specific fuel model set for each regional area, thereby using a fuel dynamic base, which I found most accurate for the purpose of fire hazard rating prediction and mapping. I adjusted these then for (fixed) fire risk calculations.

Because fuel dynamics vary rather drastically in most regional landscapes, I recommended that such fire hazard rating maps should be revised every five years.

One of the fundamental problems we have at regional level in fire prevention plans is the realistic classification of fire hazard based on a representative vegetation classification for a specific region, using a quantified norm for accurate expression of fire hazard in the regional landscape and to quantify this accordingly on a regional map.

Before fire hazard can be considered at regional level, it is necessary to classify fire hazard according to a specific fire hazard grading system. When regional fire hazard classifications are used (which vary according to the nature and percentage cover of natural fuels and land-use) it may be necessary to base this mainly on natural vegetation cover features, or a combination of both natural vegetation as well as land-use. Region-specific classifications should thus be developed after careful evaluation of requirements, also considering the SA database for real time fire behaviour calculations.

A typical regional fire hazard classification is developed for the Garden Route region (Southern Cape and Western Tsitsikamma) along the Indian Ocean coast and adjoining inland areas of the Western Cape Province (bold fuel models below are those used for the summary fuel model set used for this regional fuel model set):

A Extremely high fire hazard (red)

A1 Senescent fynbos (older than 30 years of age)
A2 Mature fynbos (20 – 30 years of age) heavily infested with *Pinus pinaster*
A3 Strandveld fynbos completely infested with *Acacia cyclops*
A4 Exit areas with mature fynbos and slash from felled *Pinus* trees unburned
A5 Areas adjoining rural settlements

B High fire hazard (orange)

B1 Mature fynbos (20 – 30 years of age) un-infested with weeds

B2 Mature Renosterveld (older than 30 years)

B3 Mature Strandveld (older than 20 years)

B4 Even-aged *Pinus* stands (excluding *P. radiata*) with partly closed crown canopies.

B5 Wetlands within plateau, mature, fynbos

C Medium fire hazard (yellow)

C1 Mature Fynbos (12 – 20 years of age)

C2 Even-aged *P. radiata* stands older than 12 years

C3 Disturbed, mature, scrub forest

C4 Mature Strandveld fynbos (older than 15 years) without weed infestation

D Low fire hazard (green)

D1 Mature, even-aged, *Pinus* stands with closed crown canopies with dominating needle mats on the forest floor

D2 Young fynbos < 12 years old

D3 Mature scrub forest, undisturbed

D4 Strandveld younger than 16 years

The above classification should also be used for the Garden Route regional fuel model file, which will form the quantified bases for the fire hazard rating to be mapped and used for the Garden Route regional area. The fuel model file should thus consist of a selection from these hazard classes A1 to D4 (see above).

Each of the fuel models should be quantified using existing fuel models from the De Ronde database (Calvin *et al.*, 2004) as well as from photoseries taken from examples of each fuel within the region, and this data should then be used as input in the BehavePlus fire simulation prediction program (Andrews, 1986; Andrews and Chase, 1986; Burgan and Rothermel, 1984). This can be done by using some options such as e.g. SURFACE for input. This will then make it possible to rank these fire parameters for typical wildfire conditions:

Flame Length (m)
Rate of Spread (m/min)
Fireline Intensity (kW/m)
Heat per Unit Area (kJ/m^2)
Maximum Spotting Distance (km)

A typical ranking outcome – as arrived at in the Garden Route region of South Africa – is provided in Table 1:

Sub-grading**	**Low fire hazard**	**Medium fire hazard**	**High fire hazard**	**Extremely fire hazard**
+	11-15	26-30	41-45	>45
.	6-10	21-25	36-40	
-	0-5	16-20	31-35	

Table 1. Fire behaviour ranking classes*

*=Total of individual ranking values of each of the fire parameters as provided above.
**=These sub-gradings (+, ., -)provide sub-classes for each main ranking class.
(low to extremely high fire hazard). This also applies to Table 2.

Classifying the fuel models according to their ranking sum produced the following results in this example, using nine most abundant fuel models from region (Table 2).

Sub-grading**	**Low fire hazard**	**Medium fire hazard**	**High fire hazard**	**Extremely fire hazard**
+	12yr fynbos	12-20yr fynbos	open Pine	>30yr fynbos exit areas
.	mature Pine	-	>30yr Renoster	
-	-	>12yr P. rad.	20-30yr fynbos	

Table 2. Fuel model allocation in classes, according to their fire behaviour ranking sum, for the Garden Route region

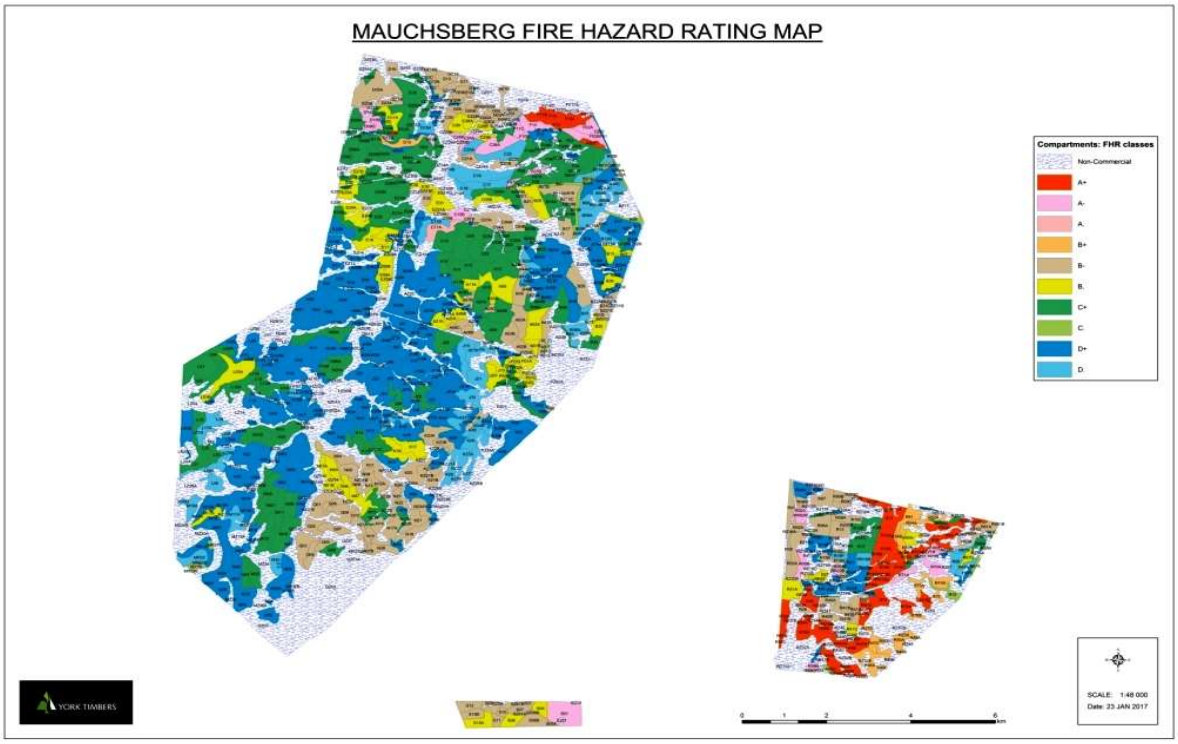
A ranking process of this nature will now make it possible to arrive at a fuel classification that can be used as a basis for fire hazard rating after adjusting the fuel classes for static fire hazard features other than fuel characteristics (such as distance from public roads and rural settlements, and positive aspects such as adjoining riverine or mountain forests, prominent watersheds or ploughed agricultural land). Table 3 illustrates the adjustments made for the Garden Route region.

<u>Mapping fire hazard:</u>
A suitable base map (or maps) should be selected to act as fire hazard maps, which should be at the smallest possible scale without having to use more than one or two maps per rating. In the case of smaller plantation units a scale of 1 : 10 000 should be sufficient, but in most cases a scale of 1 : 20 000 or 1 : 30 000 will be best for nature reserves, agricultural districts or large industrial plantation areas. Where little variation is present on e.g. larger plains, a scale of 1 : 50 000 may prove to be adequate.

Adjustment	Detail
+3	SW to SE of exit areas
+3	SW to SE of >30yr old Fynbos
+3	Adjoining SW to SE of rural settlements
+2	Approx. W or E of exit areas
+2	Approx. W or E of >30yr old fynbos
+2	SW to SE of open Pine stands
+2	Adjoining approx. W or E of rural settlements
+2	Areas adjoining main public roads/railway lines
+2	SW to SE of >30 yr old Renosterveld
+1	SW to SE of 20-30yr old fynbos
+1	SW to SE of well-managed Pine plantations (all spp.)
.	approx. W or E of well-managed Pine plantations
.	areas adjoining minor public roads
-1	Areas adjoining regularly ploughed agricultural lands
-1	Areas adjoining regularly grazed camps or lands

Table 3. Fire hazard adjustments (for risks) used to arrive at fire hazard ratings for the Garden Route region.

Colours recommended are green, yellow, orange and red to illustrate the main hazard classes, while for sub-gradings (Table 2), different colour patterns within the main colour groups/hazard ratings can be used (de Ronde, 1990).



Map 2. Fire hazard rating map for the Mauchsberg plantation, York Timbers (Pty) Ltd., in the Mpumalanga Province of South Africa (Courtesy York Timbers (Pty) Ltd).

To summarise:

(a) I am aware that there are a few fire hazard and risk-related classification methods globally available, and these might well have proved their role in mapping the fire problems in specific regions. Why I have full confidence in the methodology provided in this chapter, is that this decision-making process is based on custom (regional) fuel model bases adjusted for regional static risk factors.

(b) This FHR system was tested and put into operation in a number of South African regions and proved highly successful and accurate, with no other system that could prove me wrong over the past four decades I have implemented this system.

(c) The FHR system proposed in this book for the Garden Route region, was offered in the past for the Southern Cape as well as for the Tsitsikamma regions, but local forest managers showed no interest for this fire hazard approach at the time. However, it was implemented successfully with a few major forestry companies in the Mpumalanga and Kwazulu-Natal provinces.

CHAPTER XIII

REGIONAL FUEL MODEL DEVELOPMENT AND USE

In this Chapter I will provide an introduction to fire-related fuel model development for the Garden Route region, for a range of different purposes, such as (i) testing of firebreak or buffer zone effectiveness, (ii) the development of fire hazard rating classes with fire risk adjustment, for mapping (iii) prescribed fire behaviour predictions and (iv) specific wildfire behaviour calculations linked to fire spread parameters, including spotting.

In this case (the Garden Route region) I have provided the basic fuel model set required for direct use without the burden of knowing how this was developed, without learning about- or applying- fuel model development or using testing procedures normally required for this purpose, as I have provided this.

The information provided in these Chapters (Chapters XII, XIII and XIV) should be sufficient for this study area (Garden Route), used in this book. However, these Chapters should also provide most extrapolation material to use in other regions, particularly at a global level in the Mediterranean Zone-biome, but then some advanced further studies will be required for the development of the regional fuel model base for each study area (region).

13.1 Background

In the USA the work conducted by Richard Rothermel in the field of fire behaviour simulation is well known, and he can be regarded as the father of the BEHAVE program (Rothermel, 1972). The basic development of BEHAVE for practical use was then also published (Burgan and Rothermel, 1984), and I had the pleasure in attending a comprehensive course about this subject, presented in South Africa by Bob Burgan during 1984 at Jonkershoek, South Africa. I subsequently used this material to develop my own custom fuel model database for South Africa (unpublished).

As technology improved, the BehavePlus fire behaviour simulation program was developed still using the Rothermel mathematical models, but with a range of new options now included (e.g. Andrews, 1986; Andrews and Bevins, 2000 and Andrews and Chase, 1986). Locally some work has been published as well (van Wilgen and Richardson, 1986; van Wilgen *et al*., 1985; van Wilgen and Wills, 1988; Trollope *et al*., 2004). I developed most of the fuel models for my own custom fuel model database, for use in prescribed burning experimental burning as well as for High Court cases in Civil proceedings for wildfire reconstruction purposes, tested against real-time evidence collected during related wildfire investigations (mostly *sub justice*).

I also used the BehavePlus program for specific fuel model development during such wildfire investigations, as well as for the basis for fire hazard rating classification and mapping at regional level, to calculate fire protection break and buffer zone requirements, using the BehavePlus fire simulation options (Trollope *et al.*, 2004; Calvin *et al.*, 2004 and de Ronde *et al.*, 2004).

I am not expecting that fire managers should get involved in fuel model development and testing, and for that purpose I will provide the basic information required for the use with the Garden Route regional fire prevention plans in this book, as already developed and tested by the writer (see Table 4 below). Also see the fire hazard rating classification proposed to be used for the Garden Route region (Chapter XII).

13.2 Developing a custom fuel model data base

This fuel model data base was developed and used in Chapter XII and its data/modules used are provided in the Tables below (Tables 4 and 5):

Description of fuel	Model 23	Model 24	Model 25	Model 26	Model 27	Model 28	Model 29	Model 30	Model 31
1 Hr fuel load*	25.0	35.0	18.0	12.0	7.4	13.0	5.0	28.0	28.0
10 Hr fuel load*	16.0	5.0	13.0	3.2	3.2	15.0	1.0	1.0	12.0
100 Hr fuel load *	2.2	3.0	13.0	1.2	0.5	20.0	0.2	0.2	8.5
Live Herb fuel load*	0.5	1.5	0.5	0.1	1.5	17.0	1.5	0	3.5
Live Woody fuel load*	10.0	0.5	8.8	3.7	0.5	5.0	0.2	0	0.2
1Hr surface area- volume-ratio (SAV)**`	4800	6500	6200	5000	6200	4200	6200	7500	6200
Live Herb SAV**	4000	4000	5000	4000	4000	3000	4000	4900	5000
Live Woody SAV**	3000	3000	4000	4000	3000	3000	3000	4900	4000
Fuel depth (m)	1.5	0.5	1.5	0.9	1.0	1.5	0.5	0.1	0.8
Fuel Moisture extinction (%)	22	29	20	19	20	20	22	30	20
Dead Fuel Heat Content***	20600	17989	20485	19500	20485	20485	20300	17989	17989
Live Fuel Heat Content***	20600	17989	20485	19500	20485	20485	20300	17989	17989
*	Tons/ha								
**	Square metre/cubic metre								
***	Kilojoules per kilogram								

Table 4. A selection of (custom) fuel models used for e.g. fire hazard rating calculations, developed for the Garden Route Region (see Table 5 for full fuel model description).

For more detail how this fuel model set was used, refer to Chapter XII for (a) the fuel model description and selection used for the Garden Route region, as well as how this basis was used for fire hazard rating calculations. Later in this book it is also explained how these fuel model sets can be used with the BehavePlus fire simulation program to calculate maximum buffer zone width requirements for head fire buffering at regional level.

Fuel Model	Description
23	A1: - Senescent fynbos older than 30 years of age.
24	A4: - Exit areas with mature fynbos and slash from felled *Pinus* trees, not burned
25	B1: - Mature fynbos (20 to 30 years of age) un-infested with weeds.
26	B2: - Mature Renosterveld (more than 30 years old).
27	B4: - Even-aged Pine stands (excluding *P. radiata*) with partly closed crown canopies.
28	C1: - Mature fynbos (12 to 20 years old)
29	C2: - Even-aged *P. radiata* older than 12 years of age.
30	D1: - Mature, even-aged, Pine stands with closed crown canopies with dominating needle mat on the forest floor.
31	D2: - Young fynbos less than 12 years old.

Table 5. Fuel Model data set description, for proposed Garden Route fire prevention region.

13.3 Using BehavePlus for predicting prescribed burning fire behaviour

Using BehavePlus (BP6 is latest version at time of writing) for a planned prescribed burning exercise, whether in a fynbos, grassland or Pine plantation fuel base for fuel reduction or fire prevention purposes, such a task should be conducted the day before the burning is planned. The SURFACE module of BehavePlus must be used first, with input of the required fuel model (Tables 4 and 5), fuel moisture data, weather and topographical data (with or without the MAP option to calculate percentage slope), time, and fire spread direction information. The output will then be in the form of a fire behaviour parameter that can be expected on the planned day of the burn.

The SCORCH module, linked to SURFACE, can also be used to predict the scorch height in the case of prescribed burning application inside Pine plantation stands. Obviously the MORTALITY and SPOT modules cannot be used here, as both should never occur when fire is applied inside plantations!

13.4 Using BehavePlus for predicting wildfire behaviour

The SURFACE module can be used to provide basic fire behaviour prediction data, but for this purpose, the SIZE module should be added to estimate how long a wildfire will take to cover a certain distance, to reach a specific firebreak, or a plantation. This is particularly useful in the case of particular fire spread where large areas are covered by fynbos-covered mountains or plateau sites. The MAP option can be used to insert slope parameters. A more sophisticated fire simulation programme that can be used is FARSITE, but then a suitable GIS base of the terrain will be required, as well as hourly weather data and fuel models that cover the whole area involved (Finney, 1996).

The SPOT option is useful to estimate spotting potential when a fire is spreading uncontrolled in a specific fuel and specified terrain under known weather conditions, and is of particular value to determine what the probability will be that certain natural and artificial barriers will stop a wildfire. The SCORCH and MORTALITY modules (linked to the SURFACE module) can also be used to assist in predicting wildfire impact in woodlands or plantations. However, experience in southern Africa indicates that the MORTALITY option is not very useful in even-aged plantations, because it only covers a few pine species that occur in the sub-continent (Trollope *et al.*, 2004).

To summarise,

(a) The regional fuel model set for the Garden Route region has been provided here, and how to use this material in practice with a number of applications.

(b) For regions outside the Garden Route region, guidelines have been provided to extrapolate the results, providing some self-study and/or advance training will have to be provided for this purpose.

CHAPTER XIV

REGIONAL FIRE PREVENTION: MAPPING AND USE OF FIRE HISTORY

By this time the regional boundaries for the study area ("the Garden Route") have been determined and these have been mapped on a suitable base map. A custom fuel model base was developed and tested for the Garden Route region and suitable fire hazard ratings were calculated, adjusted for fixed fire risks, and mapped for the whole region (or sub-regions).The methodology for these products has been provided in Chapters XII and XIII.

Next will be to map and use fire history and also to map the regional buffer zones on the base maps. These procedures will be discussed under the next Chapter (Chapter XV), including the historical wildfire perimeters. The main regional buffer zones will also be numbered from B1 to B.... for future reference and development purposes.

14.1 The regional base map

To determine regional base map boundaries, significant features in the landscape have to be identified for such external lines, such as major rivers, mountain ridges and man-made lines such as main public roads, railway lines or main power lines. Considering the size of such units, the total area should be between about 50 000 and 150 000 ha, including for instance specific mountain ranges, major river lines and national roads or large wildfire areas.

With regard to the Garden Route region for example, note such features on Photograph 17 (Chapter XV) and how these significant topographical and man-made lines were used to determine regional boundaries as well as forming the bases for regional buffer zones (Photographs 18 to 20). Selection of these landscape features will have to be done considering the most dangerous wind directions experienced in the case of extreme wildfires from the past, when selecting buffer zone routes.

The regional base map in the case of the Garden Route regional study area, was broken up to illustrate buffer zoning in more detail (Photograph 17 vs Photographs 18, 19 and 20), in which case the shape of the region and its features might also assist in deciding about sub-base maps (such as in the case of the Garden Route in a western- and eastern- portion (Photographs 18, 19 and 20, Chapter XV).

14.2 Mapping and future use of fire history

Once the major recent wildfires have been mapped on the base map, (see Photographs 17 to 20) main buffer zone routes should not stop at such areas, but incorporated to be included as part of the whole regional plan over time. The sections of such buffer zones should be selected, constructed and treated first while the vegetation of the section falling within the wildfire area, should be incorporated and treated once the vegetation is becoming ready for fire-use, at which time the whole buffer zone can be treated as a whole unit for future use.

14.3 Selecting the most effective buffer zone routes

On-site studies, wildfire simulation, topographical terrain considerations and wind flow dynamic studies – together with wildfire history studies – should be used to consider where in the landscape major regional firebreaks (buffer zones) should be placed. Also important is to determine what their specifications should be, and how they should be, and how they should be placed in the landscape in relation to the most dangerous wind direction. These zones will disregard man-made property boundaries and provide continuous protection lines which can stop most (if not all) wildfires, or at least provide safe lines from where counter fires can be applied against approaching wildfire fronts.

The following main criteria have to be considered when buffer zones are placed:

- To incorporate natural protection features as much as 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.

- Incorporate recent wildfire areas.

- Place the zones (as near as possible) at a 90^0 angle with the most likely direction of maximum fire spread.

- Ensure that the buffers form continuous lines from the safest possible starting- to ending- points.

- Provide adequate width along favourable topography, from where a counter-firing line can be constructed, from where an approaching wildfire can effectively be attacked.

14.4 Constructing buffer zones and deciding about fuel management options

Main public roads have the added advantage that the tarred road surfaces are fuel free, and that road shoulders within the road reserves can also be incorporated with suitable fuel management treatments to widen such lines as part of buffer zones even further without added costs. Main flowing rivers with non-burnable vegetation (such as riverine forests) can also greatly assist as natural barriers within main buffer zones, which can be strengthened in places where natural fynbos lines can be added with suitable prescribed burning regimes and rotations.

While in mountainous terrain most fynbos shrubland can be burned in blocks as and when ecologically required, fynbos areas on the plateau are generally much smaller in size, and such areas should be incorporated in regional buffer zones where possible, and then prescribed-burned according to ecological needs. Where possible, such fynbos should be burning along continuous lines at fixed rotations.

Where fynbos is bordering indigenous forest edges, such fynbos should be burned when reaching burnable age, with fire lines burning away from the forest edge to protect forest vegetation from scorch.

To summarise,

(a) The placement and treatments of buffer zones in the landscape is an art, which can be used to advantage not only to provide optimum fire prevention, but also be prepared in the most cost-effective way.

(b) Always keep in mind to guide fire treatments within ecological guidelines and to strive for the construction of effective continuous lines in the landscape.

CHAPTER XV

DEVELOPING THE GARDEN ROUTE REGIONAL FIRE PREVENTION PLAN

The most important product of this fire prevention plan proposed for the Garden Route region, are the regional (main) buffer zone structures, provided here as guidelines for future use: Subject to adjustments where found necessary before implementation.

Most important will be to take note of the use of all features in the regional landscape to advantage of them all for the construction of the most cost-effective regional buffer zoning system possible, and how the wildfire history was integrated in this plan.

15.1 The top-down approach

At this early stage of creating the regional fire prevention plan, it is important that we identify the natural as well as artificial fire protective lines and structures in the landscape which can be used to advantage for this purpose, and to determine where these lines can be incorporated into the fire prevention plan. This requires a holistic outlook for solving effective reduction of extreme fire hazard situations in the regional landscape, without even considering fixed lines, such as property boundaries. This is important because these lines (property boundaries) are all man-made, and for fire protection purposes many will be the worst to use for such goals, because of wrong (ineffective) routes being selected for fire protection purposes!

Effective fire protection can only be achieved if the terrain (general topography, aspect and slope steepness) is properly assessed, together with the direction from where "hazardous fire approach" is most probable, such as from the general northerly direction along the Garden Route.

Then the fire history (and mapping thereof) is also totally neglected, and in particular the related changes in vegetation age of some areas, and this includes the consideration of the 2017 and 2018 wildfires into future regional planning. I fail to see such plans. Where is the regional plan for the Garden Route, as affected by the recent wildfires? I will with this writing provide some guidelines for such a future plan. However, my attempts will here only be to provide some ideas, and by no means are any of these "units" or "buffer zones" fixed. This depends on the actual vegetation cover and classification of the sub-regional areas. Remember that all this planning will have to be flexible, so that these can be adjusted in the case of future significant wildfires taking place.

15.2 Basic after fire decision-making

The most useful topographical features along the Garden Route, which can be used for fire prevention purposes, are the rivers carving through the plateau, from the mountains in the north to the Indian Ocean in the south. Then the national roads can many times also provide perfect baselines for buffer zones, simply because these lines through the landscape provide permanently-cleared (tarred) surfaces, mostly with fuel reduction measures applied on road shoulders, added to create a substantial firebreak-base for buffer zones. Some road shoulders offer mostly "green" vegetation which can also not carry a continuous fire in such a low profile fuel bed, and are normally maintained as such by the authorities responsible for these tasks.

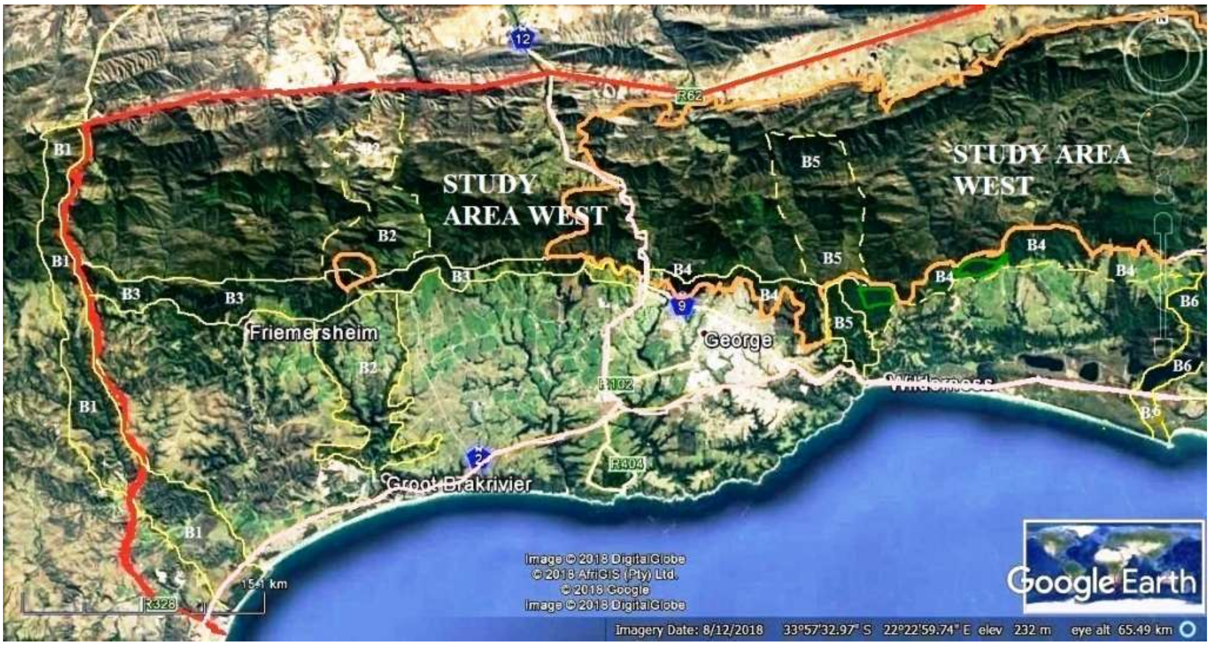
Then major wildfire areas have to be incorporated to make provision for future inclusion of sections of buffer zones, making provision for the time when such additions are possibly burnable. This has to be planned accordingly, to ensure that an effective regional fire prevention plan is maintained as such at all times, with the correct burning and other clearing methods applied at set times in a regional fire prevention plan. The buffer zones through the mountain catchments have to make provision for at least two continuous sub-zones to be burned in rotation, about four to five years apart.

15.3 Placing the main (regional) buffer zones

The strategic-correct placement of the regional (or main) buffer zones will then also be the most important basis for effective regional protection against wildfires. For this reason, the structuring and maintenance of the main regional buffer zones will always be top priority and should be in the form of continuous lines, with most-effective widths where feasible, to enable the reduction of wildfire size into smaller (more manageable) areas from a fire fighting point of view (Calvin *et al.*, 2004).

Photograph 17. The Garden Route region (excluding the Tsitsikamma), with the "study area" demarcated with a red line. The white lines are the national roads to be incorporated, while Photograph 6 can be used to planning the routes of these buffer zones to be created through the 2018 wildfire area (unknown image origin, while the author has drawn in the added lines).

` Photograph 17 is illustrating in particular how the national roads through the Garden Route region are placed in relation to the formation of the regional buffer zones. This picture also shows where the most important north-south river systems are situated in relation to the area where the 2018 wildfire has burned over. The following is a basic illustration of the regional buffer zone lines to be structured and maintained in this region:



Photograph 18. Zooming in on the western study area section, with the main buffer zones now also added, using not only the road systems, but also the topography linked to consider the routes for the main buffers, and existing vegetation and the 2018 wildfire area (main buffersB1 to B6). (Image @ Google.Earth,, while the author has drawn in the added lines).

15.4 Main buffer zone notes (western study area)

B1:

This buffer will be running west of the main tarred road between Hartenbos and Oudtshoorn, as indicated on Photograph 18. This buffer runs east of this road system at first, missing the Urban-Interface area west of this road (new sub-Urban area), which is situated closer to the Indian Ocean (Photograph 18).

The top northern portion of this buffer was mainly burned over by the 2018 Outeniqua wildfire, which will have to be incorporated when the burned over fynbos is ready to carry a prescribed fire. However, any Pine plantations at present established on the foot slopes where this buffer will run through, should be prescribed burned under tree canopies as and when required.

The centre of this buffer consists mainly of agricultural land, which is ploughed regularly and can thus be incorporated as such, with patches of Renosterveld, which have to be incorporated into the buffer by means of rotation burning, to form combined continuous fire prevention lines. The bottom (southerly) portion of this buffer has to be treated as such, as and where land-use makes this feasible.

B2:

The northern section of this buffer will run through the 2018 wildfire area, only to be incorporated when ready to be prescribed-burned in rotation when available for this in the future. The rest of this buffer zone runs through the landscape, as yet untouched by the recent wildfires. It will run along the Great Brak River gorge forming a base for future fire prevention, running from north (linking it to the Outeniqua wildfire area) to the south (as far as the Indian Ocean beach near the Great Brak River mouth) (Photograph 18).

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Where industrial Pine plantations have been established on the foot slopes of the Outeniquas where the buffer will run through, landowners will have to prescribed-burn the land falling within the buffer area, when crown canopy closure will make this possible, by means of under-canopy prescribed burning application.

The fynbos within this central portion of the buffer consists mainly of patches Renosterveld within agricultural land. The Renosterveld will have to be incorporated into the prescribed burning plan to aim at establishment of continuous fire prevention lines in the landscape, preferably on a rotational basis, whenever the veld is ready to carry such a continuous fire.

B3:

This buffer will run from the west to the east all along the Outeniqua foot slopes, connecting the Robinson Pass with the Outeniqua Pass (Photograph 18). This will in some places include the outliers of the Outeniqua wildfire, but in others industrial Pine plantations which were either burned over by the Outeniqua wildfire, or were not burned then (Photograph 10).

Where the plantations mainly consisted of *Pinus radiata* plantings these can mostly only refer to off-site establishments, which should rather be converted to *Pinus elliottii* in future rotations. The latter species are also fire resistant and can subsequently be incorporated with ease in rotational burning under their tree crown canopies.

B4:

This is basically just a continuation of the B3 main buffer zone, and the same applies here as described under the B5 buffer zone. As more of the *P. radiata* here was burned over by the Outeniqua wildfire and these stands were neither thinned nor pruned, it will be up to managers to decide how these sites will be treated in the future. However, the fact that these stands (when left unburned) also present a high fire hazard threat, should be considered, whether to be converted to fynbos, or to stands maintained in plantation-form (Photographs 18 and 19).

B5:

This north – south buffer zone does run through some vital fynbos, which has been exposed to wildfire three times during my career and should be regarded as “hazardous”. The northern section was again burned over during the Outeniqua wildfire, and – as soon as burnable – should be prescribed-burned as soon as possible in rotation. The portion south of the B4 buffer zone should be incorporating the Kaaimans River gorge, with added fynbos burning on its sides, for maximum protection, burned in rotation west and east of this gorge as and when fynbos is available for such treatment (Photograph 18).

15.5 Main buffer zone notes (eastern study area)

B6:

This buffer is situated with the Goukamma river and valley as its base, from a general northerly to southerly direction. Most of this valley is covered by ever-green pastures apart from the wide river itself, while also presenting some unburned and burned over indigenous shrubs covered by the 2017 Knysna fire (Photographs 18 and 19).

B7:

This buffer is an automatic choice as (a) the central section of this buffer is mostly formed by the Knysna forests, which is a perfect natural protection buffer and (b) the buffer north of this was mainly burned out by the Outeniqua wildfire (both the old fynbos as well as the Industrial plantations). The latter will have to be treated with fire whatever its vegetation base may be: fynbos when reaching prescribed burning age and the plantations (most probably *P. elliottii*) when crown canopies are closed, and then in two year rotation (Photograph 19).

The buffer-part in the far south of the land has mostly been covered by informal settlements, but these townships need to be isolated from the original Knysna town by means of effectively-cleared fire breaks, as will be the Urban Interface between the townships and the Kruisfontein plantation in the east. Here whole compartments have to be treated with fire at least on a two-yearly rotation and the areas there burned over by the 2017 Knysna fire, preferably re-established with fire-resistant *P. elliottii* stands.

B8:

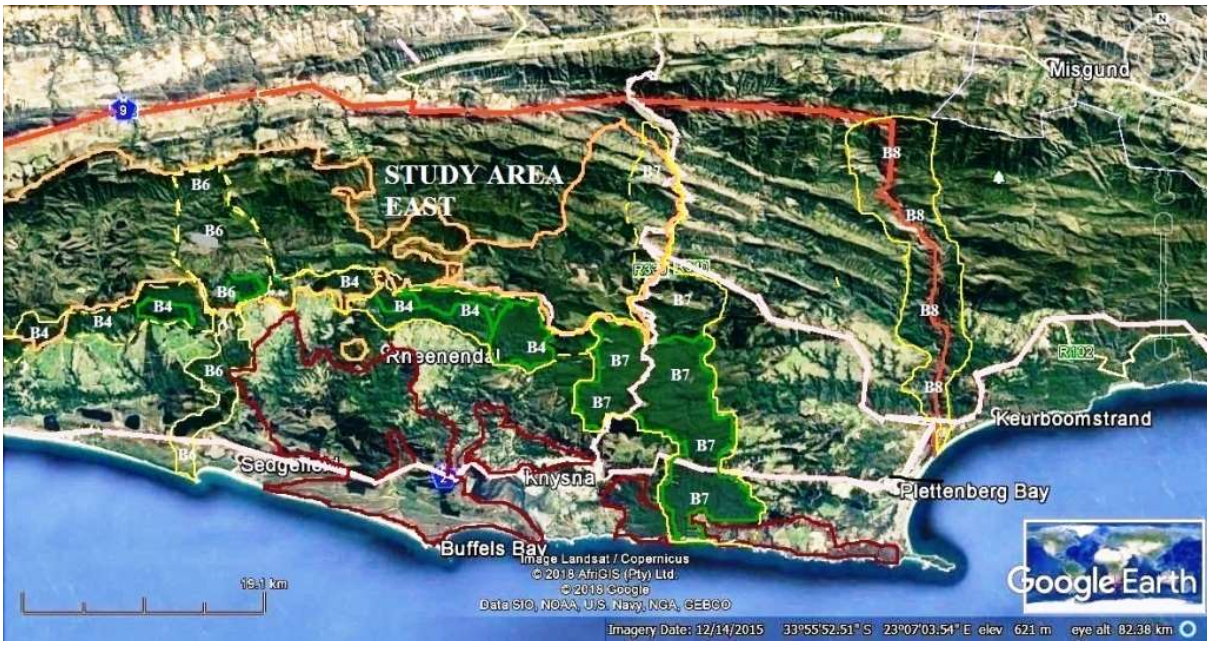
This buffer runs from north to south as indicated, with the Keurbooms River and its surrounding indigenous forest (or scrub forest) as a natural fire prevention buffer, with no additional treatment required. The northern section of this buffer however, may have some old fynbos which needs to be burned to form a continuous firebreak with the rest of this line. However, if too old, such senescent fynbos might have to be isolated in the form of cut-off hazardous islands (Photograph 19).

Photographs 17, 18 and 19 are by no means final, because of the “top down approach” used to remain flexible, and I am sure there is room for improvement. Also note from Photograph 18 that the area burned over by the 2017 Knysna wildfire area has been demarcated on the picture with a dark-red line.

15.6 Within-buffer zone policies

The objectives for within-buffer zones policies will always be to prescribed-burn the available vegetation fuel strictly according to schedule, which has been developed to provide the least fuel loading for sub-zones, and also to create within-zone rotations, to have always effective sub-zones being non-burnable at any one time in the form of continuously-cleared line strips.

The objectives will here be not to create buffer zones which are completely fuel-free all the time, because this will not be feasible. However, areas within buffer zones should always be creating lines from where a wildfire can be fought, or within which spotting can be brought under control in time when extinguished by fire fighters, before becoming uncontrolled.



Photograph 19. Zooming in on the eastern study area section, with the main buffer zones now also added, using not only the road systems, but the topography linked to consider the routes for the main buffers, also accounting for existing vegetation and the 2018 wildfire area (main buffers B4 to B8). (Source: Google.earth image, while the author has drawn in the added lines).

Another important issue to be considered will be the Legislation required with regard to the different properties; private and Government land, where portions of this land will now be covered by the main buffer zones (see Photographs 18 and 19). Most important will be to streamline Legislation at first to make "emergency fire prevention measures" possible under disaster management Legislation.

Central Government will have to be consulted regarding the control over buffer zones where national roads are situated. Also to be considered should be where Provincial Government is the controlling body, where e.g. the overall control over the fire prevention plan is required. The local Government (municipalities) will have to be consulted regarding control over the land falling under their control, particularly in connection with the routing and maintenance of the main buffer zones through the land they are responsible for.

The overall control over the creation and maintenance of the buffer zones for the region involved, should be a shared responsibility between Central and Provincial Government, and the Garden Route region (study area) should be used as a unique example to counteract the impact of the recent 2017 and 2018 wildfire disasters, and to ensure no repetition of these crippling events.

This “master plan” will thus act as a “White Paper” for extrapolation to other regions within the Western Cape Province, and also to other SA Provinces. Of course the Western Cape Provincial Government should feel free to extrapolate the “Garden Route plan” to other regions within the province as and when required, with the required adjustments as and when needed, as their staff will also have to be trained to apply this further without guidance.

Subsequently, the WP provincial Government should seriously consider appointing and training a few “champions” for control over the new planning approach. For this purpose, we can discuss my personal involvement to make this possible, including the use and development of fuel model sets for specific regions. I also hope that this handbook can lead to the use of the methodology at National level within South Africa. More detail will follow under Chapter XIX.

To summarise:

(a) This chapter provides important guidelines for the structure of the Garden Route regional fire prevention plan, with further recommendations about its implementation control under Chapter XIX.

(b) The layout and structure of the regional buffer zones must be mapped, and should form the basis for future implementation and planning.

CHAPTER XVI

DETERMINING REGIONAL FOCUS AND PRIORITIES AFTER WILDFIRES

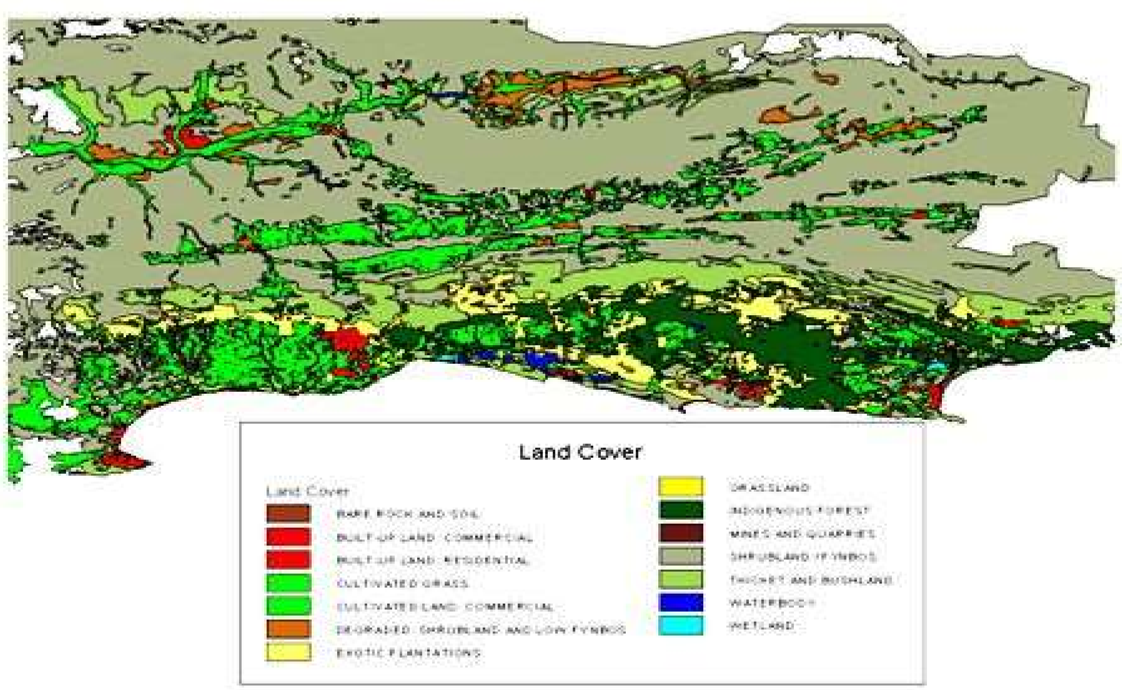
More practical recommendations have been provided in this chapter about regional fire prevention, with the focus on regional (top down) approach and use with identification and use of pre-determined priorities.

A few buffer zones of the proposed Garden Route region fire prevention plan were used, because these buffers were constructed through both areas affected by the recent wildfires, as well as land not yet affected by major wildfires, planning will in the distant future for maximum effectiveness, as examples.

16.1 Assessing wildfire areas and unburned regional land

Firstly, we have to assume that we are working on a regional fire prevention plan, which will include the area burned over by recent wildfires, as this is still our goal: To put into operation an effective regional plan which will make provision for all dynamic vegetation changes with age over time, starting with the age distribution from year one after the most recent wildfires were considered. Then the new vision of the plan has to be drawn up along the lines set out in the previous six chapters, taking the Garden Route region again as an example.

An assessment of land-use can greatly assist in this evaluation of region land (Map3):



Map 3. Assessment of land-use of the Garden Route region (unknown source).

16.2 Placing regional buffer zones across burned/unburned land

In the Garden Route region, a good example to look at can be found on Photograph 15, buffer zone B5, the northern section (demarcated with a broken line). This is the part which runs through the 2018 wildfire area, which particularly burned over the Outeniqua Mountain range. Map 3 can assist when considering the land-use of the area within the B5 buffer zone.

For the time being, we have to consider that the first burning application will only be when the fynbos reaches 12 years of age, thus during the year 2030. However, the most important action will be to plan to burn the western section of this part of the buffer zone will have to be burned as a first rotation during 2030, and the second rotation (eastern section) during 2033/2034. Cleaning of fuel-free and wide guidelines for the first burning rotation can be prepared during 2028/29, to provide a safe burning line to start a counter fire from, in case an early wildfire occurs earlier than 2030.

The southern section of the B5 buffer zone will have to be prepared, concentrating on all prescribed burning between now (2020) and 2027, focussing on the plateau fynbos within the southern portion of the B5 buffer, as well as any road-shoulders or other fuel vegetation within this B5 buffer section, such as suitable Industrial Pine plantations (Photograph 18).

The B2 main buffer zone offers similar solutions than the B5 buffer, but here the southern section of this buffer will run mainly through agricultural, cultivated land, or grazing land (Photograph 18), with smaller patches of Renosterveld in the drier climate, closer to the Indian Ocean.

The B6 buffer zone (Photograph 19) has a similar northern portion affected by the 2018 wildfire, which can be approach and plan as for the B2 and B5 buffers. However, the southern portion bordering the Outeniqua Mountains, then runs through a mixture of Industrial plantations, Renosterveld and scrub forest, which should be treated during the 2020 to 2027 period. The far southern section of this buffer runs mainly through the vleis (particularly the Swartvlei), which offers natural protection against major wildfires (Photograph 19).

16.3 Considering the 2017 and 2018 wildfire areas as a whole

As these areas form about 20 to 25% of the Garden Route region, the regional fire prevention plan work for the future should be concentrating only on the unburned areas outside the 2017 and 2018 wildfire areas, for the period 2020 to 2027, as indicated on Photographs 18 and 19. This means identification of “hot-spot” fuels within the southern portions of the regional buffer zones, concentrating on old fynbos sections and the road shoulders along the national and regional roads, as well as unburned Industrial plantations, where falling within the main regional buffers.

Otherwise, in the Knysna wildfire area, the fire prevention work should be concentrating on the Urban Interface problem areas and sections where the main buffer zone lines fall outside this wildfire area. As far as the Outeniqua wildfire area is concerned (2018 wildfire) no fire prevention work will be required here unless main guidelines for future buffers must be attended to (starting 2017) with rotational burning of buffers not to start earlier than during 2030.

16.4 Planning and budgeting for the regional plan

2020 Should be the target year for drawing up and tabling the Garden Route fire prevention plan, while this year should also preferably be the starting year for regional buffer zone construction. This year should then also make provision for formal drawing up and regional approval of the first 5-year regional plan, with budgets, management structure etc. Any further meetings, discussions etc. should preferably be targeted for 2020, with fully operation programmes also soonest, preferably 2020 latest 2021. It should be remembered that work is planned to include wildfire areas again in the regional fire prevention plan by 2017, which then only leaves the years 2020/2021 to 2027/2028 (seven years) to get all regional work done in the unburned areas of the region.

With regard to fire prevention work priorities, it is thus crucial that the fire hazard rating maps for the unburned areas of the region are completed soonest, as this is the tool to be used to determine, identify and map first priority “hot-spots” which should be attended to in terms of fire hazard reduction action plans as top priorities.

To summarise:

(a) Always go back to the proven holistic “top down approach” to start working on a specific planning issue, also using the guidelines provided here.

(b) The incorporation of major wildfire history in medium and long-term fire prevention plans is of particular importance, so please take note of this.

CHAPTER XVII

DRAWING UP, MANAGEMENT AND APPLICATION OF THE REGIONAL FIRE PREVENTION PLAN

This process will now finalise the products and methodology for holistic regional fire prevention, with a proper planning base and handbook. Sure some advanced training can puts the "dots on the i's", but with this book I hope fire managers can find their way to success.

17.1 The strategic fire prevention plan

Certain realities are here to stay, which should be considered in developing an integrated fire prevention plan:

- Increased population pressure and subsequent increase in fire hazard as more and more people infringe on the natural and plantation environment.

- Global changes in weather patterns will have to be accepted as a fact and planners will have to consider these issues in the future seriously.

- Urban Interface problems must be identified and an action plan has to be developed by local authorities.

- Weed control programmes on a regional level must be implemented to address factors such as biomass accumulation (and subsequent fire hazard).

- Continuous attempts are necessary to come as close as possible to optimal ecological requirements, also in fynbos in particular. Realistic compromises with the ecological burning programme must be made to reduce the wildfire hazard to acceptable levels.

A fairly new approach to fire prevention has to be followed as a cost-effective vehicle that provides a dynamic buffer zoning system, which reduces wildfire hazard significantly and also provides an effective base for fuel management. This can be achieved by making use of regional fuel and fire behaviour modelling, fuel classification and fire hazard rating within ecological principles where possible, or otherwise by means of ecological and fuel management compromises of which the use of prescribed burning forms a key issue and management tool. Furthermore the integration of riparian zones and conservation programmes into fire protection systems will result in optimum construction of multi-purpose buffer zones.

17.2 Evaluating existing fire protection measures

In the case of the Garden Route fire prevention region, such assessment procedures will not be possible anymore within the areas burned over and wiped out by the 2017 and 2018 wildfires experienced and because most (if not all) of these firebreaks proved to be ineffective. Subsequently, within these wildfire areas such fire prevention planning will have to start from scratch.

Within the unburned areas of this region, such evaluation programmes should be carried out before regional fire prevention measures are constructed and applied and be based on the fire hazard phase and the developed long-, medium- and short term fire prevention programmes planned, together with some added measures and considerations such as:

- The placement of existing fire belts in the light of the new requirements.
- Riparian zone requirements.
- Nature conservation requirements, such as special regimes for natural heritage sites and wetlands.
- Financial constrains and the cost-effectiveness of the recommendations.

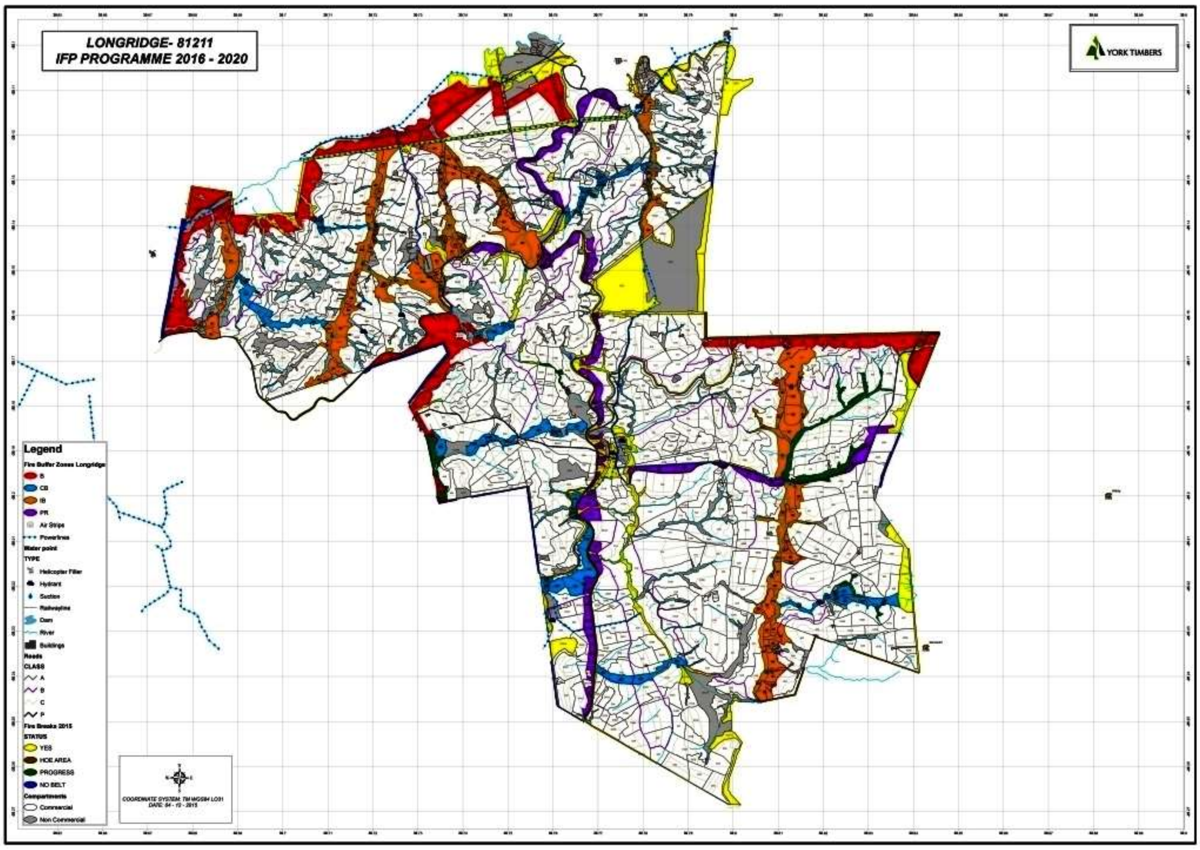
This process follows immediately after the fire hazard rating evaluation processes described earlier, and starts off with a field inspection on the ground, sometimes with the assistance of aerial inspections. The bases for these decision-making procedures will be the already-placed main buffer zones, which will now have to be planned in more detail at a smaller scale, as well as the outcome of the fire hazard evaluation. In the case of the Garden Route regional strategic plan, Chapter XV with specific reference of Maps 16 to 19 will have to be considered and adjusted where possible.

An example of such a fire prevention plan-part has been provided in Map 4 below. In the case of the Garden Route regional plan, the procedures for constructing the regional buffer zones have already been preliminary placed, and these will just have to considered and adjusted where found necessary after the field inspections. The basic guidelines for this, for the Garden Route, have been provided earlier in this book in Chapter XV.

17.3 External fire protection requirements

Once the buffer zones have been placed in the landscape, attention should be given to other external fire protection, property boundaries (with deviations thereof), management units, ownership and fire managers responsible for fire protection and maintenance. One important consideration will be the most dangerous wind directions, which will in the case of the Garden Route region by the Bergwind direction ranging from northeast (through north) to northwest.

Along dangerous external firebreaks, main regional buffer zones will normally be placed including the “old” (outdated) firebreaks as well as additional fire management units, according to requirements as well as available fuel availability. These external buffer zones will include adjoining land from neighbouring properties, which inclusion (and implications) will have to be negotiated with applicable landowners, including any route deviations from existing property boundaries, considered to be more effective in terms of fire prevention.



Map 4. Regional fire prevention map for the Longridge plantation, near Sabie, Mpumalanga Province (Courtesy York Timbers (Pty) Ltd.).

In the case of Mpumalanga, the dangerous wind direction runs from north through northwest and then to west. Subsequently, strengthening of buffer zones facing this dangerous direction were significantly better protected against wildfires, as can be seen clearly from Map 4 above (Calvin *et al.*, 2004).

17.4 Reducing the area at risk

This applies to the area within external boundaries and can include Industrial plantations with compartments/blocks or farms subdivided into different camps/cultivated lands. It can also be applicable to subdivided nature reserves, hunting farms, rural areas, mountain catchment areas or other forms of natural grasslands or fynbos sections, bush or forest.

It is important that the areas at risk within fire management units is reduced as much as possible to restrict fire spread of wildfires, which either originated within the unit or from outside its external boundaries. This can be done by identifying effective, continuous fire protection lines, which can be used as part of the internal fire protection system. Natural protection lines should be used for this purpose where possible, extending them with additional firebreak sections where these lines are not continuous, or present where they form gaps. In natural vegetation, existing wetland lines, rivers, mountain ridges and road systems should be used to advantage where possible to achieve this.

To calculate the results of internal fire protection improvement, the areas of individual areas at risk should be calculated (in terms of ha) before and after fire protection adjustments have been applied, to arrive at an average area at risk before and after improvement measures. This comparison can also be used to advantage to see if any of the larger units may require further attention to reduce the risk area(s) (Calvin *et al.*, 2004).

To summarise:

(a) Here we thus have some more important considerations when bringing a plan together, also considering fire prevention requirements for the directions where most dangerous wildfires normally come from.

(b) Map 4 is an example how a combination of Industrial plantations and riparian zone with conservation requirements etc., have been integrated in one fire prevention plan.

CHAPTER XVIII

PRESCRIBED BURNING INSIDE TIMBER PLANTATIONS: PLANNING, APPLICATION AND ASSESSMENT OF RESULTS

I have selected prescribed burning inside industrial timber plantations as a separate Chapter in this book, because the burning techniques deviate significantly from the normal burning procedures such as in natural savanna, fynbos and grassland. Secondly – although the Industrial plantations only form a relatively small portion of the Garden Route region – they are many times strategically well-placed in the landscape, where no other fuel reduction is possible, for a number of reasons.

In the Garden Route region the future of the Industrial (Pine) plantations is also threatened because heavy losses were experienced in some prominent plantations, mainly as a result of "fire exclusion": An issue already discussed earlier in this book. In other plantation areas, Pine stands are already in the process of "exit" procedures to be converted to fynbos, because they are regarded as uneconomical. It is thus clear that forestry in the region is being threatened, something I strongly disagree with for a number of reasons, I do not feel like discussing in this book.

The "anti-plantation people" have (after the latest wildfires along the Garden Route) argued that they are too vulnerable against wildfires and even "increase regional fire hazard". This state of affairs can directly be contributed to the "fire exclusion", something this crowd does not want to hear. On the contrary, as I will point out in this book, these plantations can indeed be used to advantage to strengthen region fire prevention.

Prescribed burning inside Pine plantations can thus serve a multi-purpose in the Garden Route region, and a local industry can be saved, with many job opportunities, so vital for this area! To top it all, under tree canopy burning is so much easier and safer than any other prescribed fire application, as I will set out below:

18.1 Comparing prescribed burning application under Pine tree canopies with prescribed burning inside other fuel/vegetation types in the region

This comparison is mainly discussing fire application inside Pine stands, vs prescribed burning inside fynbos shrubland. Thus what we have to determine is whether the latter consists of mainly prescribed burning of a fynbos shrubland within buffer zones, or in the form of block burning. In the case of the first option, this is about fire application within Pine stands, mainly consuming forest floor fuel under the crown canopy of trees, with a certain degree of crown canopy closure (de Ronde, 1988; de Ronde *et al.*, 2004)..

Fynbos burning is normally well-known by fire managers in the Cape regions, with the technique normally being applied in the form of a combination of circle burning, with some within-area spot ignition where some sections of the burn are only patchy burning. However, the circle firing technique is the one normally avoided when prescribed burning is applied inside Pine stands, with the exception of burning of slash, after tree felling and timber exploitation. I will not discuss the issue of prescribed burning of fynbos in this chapter, as I assume the fire managers/fire bosses do have experience with this type of burning.

In most Pine stands, the most dominant "fuel drying manipulator" is the dominant tree crown canopy degree of closure of the crowns, which reduces the (normally) living fuels growing in abundance on the forest floor at early stand age, suppressed when crown canopies close, to form eventually a prominent compact, dead, fuel needle mat.

18.2 Assessment of Pine tree stands and selecting the correct fire treatments

Here I will concentrate on the managed Pine stands found on the Garden Route regions' plateau, but also on the southerly aspects of the foothills of the Outeniqua Mountain range. The main criteria to be considered will be (i) Pine species, (ii) stand age, (iii) degree of crown canopy closure, (iv) fuel characteristics on the forest floor and (v) occurrence of pruning, thinning and/or previous tree rotation slash leftovers. I will provide the main restrictions/advantages in each case, with type of prescribed burning treatments recommended, and when the technique(s) should be applied.

a. <u>*P. radiata* stands planted on the mountain foothills < 15 years stand age:</u>
   Normally no crown canopy closure present and another characteristic is that the tree species is vulnerable for cambium damage when exposed to fire temperatures. No fire application is recommended in these stands.

b. <u>*P. radiata* stands planted on the mountain foothills > 15 years stand age:</u>
   Crown form normally too thin to form a high degree of crown canopy density and closure, although some partly crown closure is possible where no P-deficiencies are present. As a precaution against cambium damage, rake available fuel away from stems and spread between tree rows. Only fire allowed between trees (at least one metre away from tree stems), and then only burning by means of backfire application, or in the form of spot ignition.

c. <u>Natural regeneration of *P. radiata* stands on the plateau < 15 years stand age:</u>
   NR will provide patchy stems per hectare, which will be spaced at least once, providing some thinning slash. No prescribed burning will be recommended at this early tree stem age.

d. Natural regeneration of *P. radiata* stands on the plateau with 15 – 20 years stand age:
   Stands should only be incorporated with prescribed burning if falling within main buffer zone areas, and then only if all slash is spread thinly between trees and then patchy burned only once before clear felling

e. Natural regeneration of *P. radiata* stands on the plateau > 20 years stand age:
   All slash to be raked away from tree stems and then spread between tree rows between prescribed burning application combinations of application methods allowed to be applied according to best requirements on sub-sites.

f. *P.elliottii* planted (all sites) < 10 years stand age:
   Only allowed prescribed burning (backfire method only) if situated within key buffer zone sites with acceptance of some degree of crown scorch.

g. *P. elliottii* planted (all sites) 10 – 15 years stand age:
   Can be prescribed-burned, but only the backfire method should be applied where crown canopy not completely closed, where crown scorch can be expected.

h. *P. elliottii* planted (all sites) > 15 years stand age:
   Prescribed burning can be applied normally at a 2-year rotation or as and when required, using any burning method, provided tree crown canopies are closed.

18.3 Prescribed burning – stand assessment before application

The following procedures should be attended to within approximately one week before prescribed burning is planned to be applied:

- Determine boundaries of stand to be burned and determine fire protection cleaning required along these lines, before burning is applied.

- From mature stands: Forest floor inspection for moisture gradient humus (H) laye status and - in absence thereof - top soil moisture which should be present before burning is applied at all.

- Determine estimated height of living crown foliage upright from the forest floor.

- Estimate percentage crown canopy closure.

- Determine and sketch of major patches of living vegetation, where backfire only has to be used as burning technique.

- Make notes of any significant fuel in suspension from e.g. pruning and/or thinning slash leftovers.

- Make notes of significant changes in slopes and where to apply strip-head firing, and where only backfires should be applied.

- Identify where fire ignition should start (with test burn applied) and where backfire lines should be created as starting line, also considering wind direction expected at time of burning, and an alternative backfire line if wind direction is different (edge burning).

- Calculate maximum flame height to be allowed from a prescribed burn, from lowest living crown height and 1 : 7 flame height/scorch height ratio.

- Determine if preliminary edge burning is required, if difficult fuels are encountered.

- Draw up a prescribed burning plan, with notes about burning techniques to be applied, indicated on a sketch map from the stand to be burned.

- Brief the fire boss who will be in charge of the burning operation or – alternatively – take him along when assessing the stand to be prescribed burned.

18.4 The following prescribed burning techniques can be applied inside even-aged Pine stands:

(i) Edge burning

This is basically a set of burning procedures when starting to prescribed burn a Pine stand. It always starts with a test burn at the stands' corner where to first ignite the backing fire for a safe start against wind and/or slope. When starting burning early during the morning, this provides an idea what type of fire behaviour can be expected on the tree compartments' edge, to see if burning along this line is safe against the wind (Photograph 16).

Because of the above "test and see" burning procedure, this will also normally be the time when to estimate what fire behaviour will be like inside the stand, when the edge burning exercise has been completed. Most of time, the early morning's fire behaviour could be restricted to burning the edge, and it will only be when conditions warm up during the later part of the morning, if the rest of the stand can be burned at all, or many times burning has to be postponed with one day. If to be postponed, then at least the safe edge burning phase has been completed, and the burning team can start straight away to burn inside the stand with strip-head firing.

(i) Striphead burning

This method of prescribed burning application, is best illustrated in Sketch 1 below, and then shown in spreading progress on Photographs 21 and 22. This method is particular useful because the strip width can vary when flame height has to be increased or reduced, depending on scorch height requirements, to keep scorch height out of the tree crowns.

The burning method is then also mostly applied with two fire igniters, to speed up the burning process, and not only one as is illustrated on sketch one. However, to keep proper control over the burning process, the first person igniting the line may not be too far ahead of the second person igniting, and always check if the distance between the two remains constant. The fire boss can also slow down the "ignition speed" when walking into fuel structure variations needing strip width reductions.

Photograph 20. Edge burning in progress in a mature *P. elliottii* stand in the Tsitsikamma. This fire line is producing a maximum flame height of approximately 0.8m. As the fire line progressed to burn from left to right in the picture, this was reduced to an estimated flame height of approximately 0.1m when progressing about 2m inside this stand, because of the higher moisture of the fuel there protected by the crown canopy. This burning technique is normally applied first before burning is applied inside the stand. The technique can also be used as a stand-alone method within certain stands as a safety measure, where difficult fuels are found (Photograph taken by C. de Ronde).

(i) Backing fire

In difficult fuels, the backing fire should be the only burning method to be applied. Here a 6-year old *P. patula* stand with highly aerated pruning slash is being subjected to a high intensity backing fire as an experimental burn. Although the backing fire keeps the flames as low as possible, crown scorch was common in the lower crown branches, and up to two-year tree height increment was lost as a result (for examples of backing fires, see Photographs 3 and 19).

Photograph 21. Striphead burning in progress in mature *P. pinaster* stand in the Tsitsikamma. The fire line in the centre of the stand has just been ignited with a drip torch. Note controlled flame height, and the backfire line (created first) visible in the background (Photograph taken by C. de Ronde).

Photograph 22. Another striphead burning operation in progress inside a mature *P. elliottii* stand in the Tsitsikamma. This compartment was broken up in sub-blocks with cleared lines to act as block boundaries (see cleared guideline between the two burners). Photograph taken by C. de Ronde.

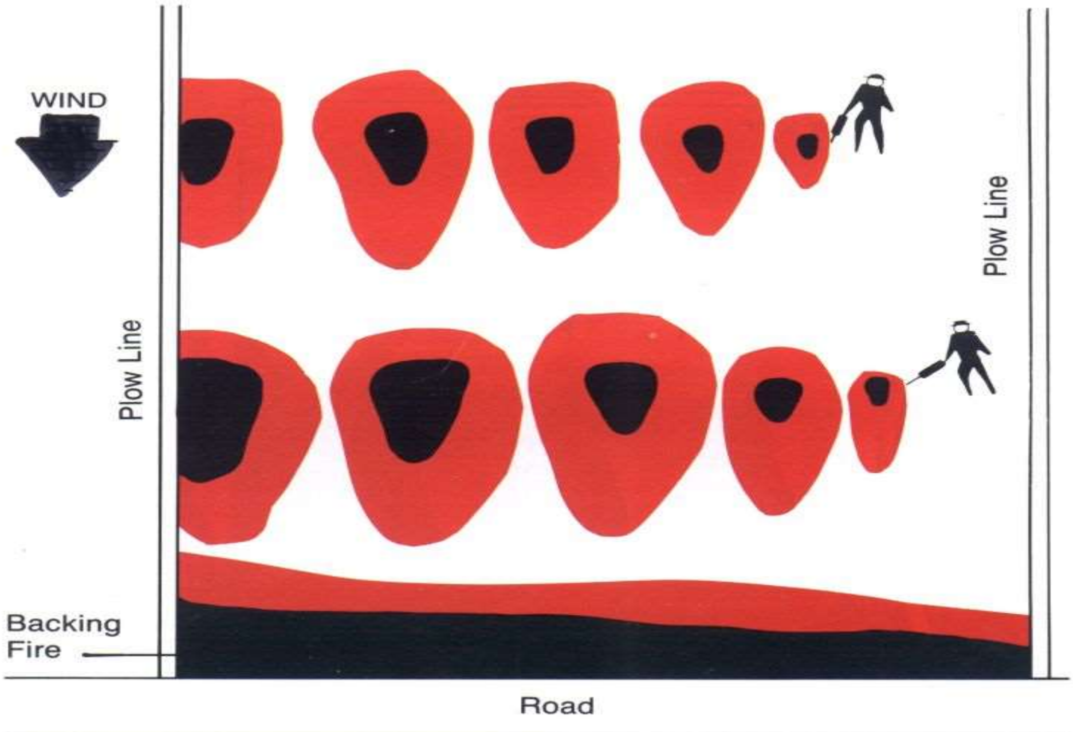
Photograph 23. Backing fire in progress in 6-year old *Pinus patula* stand in NE Cape. This experimental fire was applied in heavy pruning slash. The stand suffered from a common, high, scorch percentage in the tree crowns but – contrary to expectations – the trees survived the fire, although they lost about two years of tree height growth as a result of the high percentage of crown scorch (Photograph by C. de Ronde).

Photograph 24. A high intensity back burn (backing fire) in progress inside a mature *P. elliottii* stand to burn-out patches of the *Gleichenia polypodioides* indigenous fern weed spreading in this stand (Photograph taken by C. de Ronde).

Photograph 25. A test ignition as part of grid burning exercise inside a 50-year old *Pinus halepensis* stand, between two very light surface fires, with gaps left unburned (Photograph taken by Prof. Vittorio Leone).

Photograph 26. Spot burning of pruning slash stacked in low profile heaps, or in short-distance rows inside a mature *P. elliottii* stand in the Tsitsikamma forest region (Photograph taken by C. de Ronde)

Photograph 27. Grid burning inside a mature *P. pinaster* stand in the Tsitsikamma forest region. Note low profile (but continuous) flame lines (Photographs taken by C. de Ronde).



Sketch 1. Illustration of grid burning in progress. Note wide backing fire at the bottom of the sketch. Distances between ignition point to be set at allowing surface fires to be continuous, while flame height should not scorch crown needles from lower pine tree crowns (Unknown artist).

(ii) Grid burning

Grid burning is a technique which can only be applied in easy fuel types to speed up the burning progress. Use of this method is best illustrated in Sketch 1, and on Photograph 23, 24 and 25. Note on sketch 2 that the backing fire is still used when starting the burning operation, before starting with the grid.

The most important issue will be to test which optimum grid point width to use to ensure (i) no high intensity fires and in contrast (ii) to get complete fire cover over the whole area to be burned. For this reason, the first grid must be observed carefully when applied in a restricted area, and thereafter adjusted and "tuned-up" until satisfied that optimum widths have been achieved.

(iii) Circle burning

This burning technique should only be applied in broadcasted clear felling slash after the logs have been cut out and removed by means of road transport. This technique should never be applied when burning stands under crown canopies. The other provision that should also be made before circle burning is applied is that all slash should be properly broadcasted by hand, to ensure that no flaring potential exists when burning is applied (Sketch 2).

(iv) Chevron burning

This burning technique should only be applied in broken, mountainous terrain with varying aspects (such as in typical "koppies" landscape). Starting with three to six drip torches from the top, these "igniters" should descend from the top of each "koppie" in star formation simultaneously, thus basically the technique is similar than strip head firing, adjusted for slope/aspect variation.

(v) Concluding notes

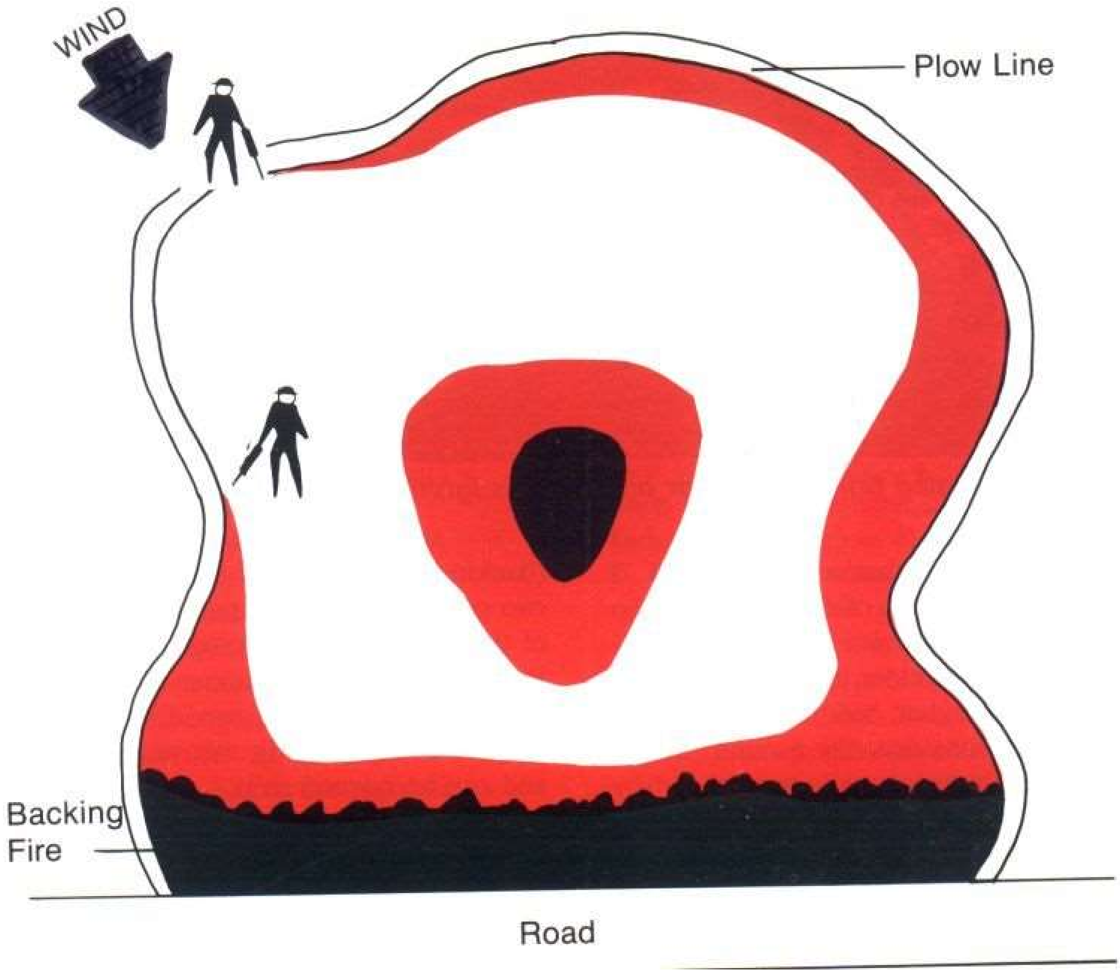
When applying prescribed burning inside Pine stands, combinations of the above burning techniques should be applied as and when required, thus where fuel loading variation varies significantly. Before such stands are burned, the fire managers should make a note of such requirements before such burning is initiated.

18.5 Post-prescribed burning results assessment

The post-prescribed burning results assessment should be applied within Pine tree stands exposed to prescribed fire:

- Inspect for any smoldering spots which should be attended to. If deep smoldering is detected, the stand should be guarded and watered regularly on these spots until adequate rain has been recorded on this site.
- Inspect of boundary breaks are all safe and "out".
- Inspect the stand for any patches or areas which were left unburned and should be re-ignited to complete the burning operation.
- Inspect the forest floor to estimate percentage of profile consumed by the fire applied.

- Inspect (and map if necessary) crown scorch occurrence/pattern/height into the crowns.
- Ensure the results were achieved and write a concise report for the record.



Sketch 2. Circle burning in progress. Note wide backing fire burn at bottom of picture, required for safety reasons. Spot ignition in centre of area burned is optional (Unknown artist).

Photograph 28. Burning of slash heaps stacked within a clear felled Pine stand in the Mpumalanga Province. Stacking slash in heaps and then burn this, doubles tree establishment costs, because of costs of heap stacking and slow burning procedures with higher costs of safety measures required for dangerous flaring potential of fuel heaps (Photograph courtesy of Working on Fire).

18.6 Special burning operations for specific goals

To avoid scorch height where tree crown canopies are low near the ground surface, prescribed fire can successfully be applied when pruned branches are still green (Photographs 30 and 31). The time of burning application is crucial here, as the pruned branch needles need to be "green" so these can have a smoldering effect on the dead fuel underneath it, on top of the forest floor. Once these needles have been dead and cured, such stands cannot be prescribed burned as the added dry fuel in suspension will increase fire intensity bringing in the probability of killing of trees in the process.

It is thus necessary that the fire manager keeps track of the pruning program, and – when such a stand has been put on the prescribed burning list – will have to be burned when (i) the needles on the pruned branches are still green and (ii) weather conditions are suitable for such burning to be applied successfully.

Photograph 29. Picture of a 10-year old *P. elliottii* stand hours after prescribed burning application. The pale green to light brownish crown canopy needle colour indicates when crowns were scorched by the heat from the fire, which was in this case only in a few patches of the stand where crowns were only partly closed. Subsequently, the light intensity/patchy scorch did no harm to the trees (Photograph taken by C. de Ronde).

Photograph 30. Under canopy burning in progress in "green" pruning material in seven-year old *Pinus patula* in the North-Eastern Cape region (Picture taken by Neels de Ronde).

Photograph 31. Same stand as for Photograph 30, after the fire was applied. Note the needle on the branches still being "green" in colour, indicating the light degree of fire intensity (Picture taken by Neels de Ronde).

To summarise:

(a) The application of prescribed burning inside Pine plantations requires some knowledge of fuel dynamics and related fire behaviour to make burning results for specific goals feasible.

(b) It is particularly the advantage of the crown canopy of trees which must be understood and used to advantage for safe burning and flame height control.

(c) Prescribed burning of *Pinus radiata* requires some specific caution as the species is rather susceptible to fire damage. However, if these trees' restrictions are understood, optimum use of fire can be achieved with good planning and use of suitable burning days.

CHAPTER XIX

MANAGEMENT OF THE IFP PLANS: WHO RUNS THE SHOW?

The present situation is that each landowner (or manager in charge of a specific property) is responsible for fire protection along property boundaries of neighbouring land, and can be held liable for any fire escape from the property under his/her control if damage is caused as a result.

There is at present no overall regional control for all the regional fire prevention measures required at a controlling level in South Africa, as this responsibility has been placed on the doorstep of landowners or property managers with no "regional master plan" in operation at e.g. the Garden Route at regional level.

The purpose of this Chapter will be to critically look at the operational value/problems in a specific region (such as here the Garden Route region) and to arrive at a proposed improvement of the infra-structure for fire prevention management and control purposes.

Readers from countries other than South Africa, should take note of their fire prevention responsibility spread in their region(s) and then consider if there is place for structural responsibilities of fire prevention at all levels. From a controlling point of view, please consider if the Urban Interface problems should also be controlled by their local Municipal fire fighting resources.

19.1 Assessing who should be best suited to be controlling regional fire prevention?

This assessment will first of all decide about the most suitable organisation(s) for these tasks, and then "who" is proposed to do "what", regardless existing staff, training requirements or existing budgets. This goes for Central Government through Provincial Government, to local Municipalities and private property owners with their staff.

(i) Central Government (DAFF)

The existing management staff in the Western Cape Province of South Africa is (as things are standing now) one FPO for the whole area, which is off course far too little. However, this person should be considered as the key role player when adjustments or changes in Act 101 of 1998 are proposed for improved regional fire prevention. He should also be the key negotiator between Government (SANRAL in this case) and the local controlling fire manager for the Garden Route region, regarding the integration of National road reserves into regional buffer zones.

(ii) Western Cape Province Government (CapeNature)

This organisation is best placed for overall control over the Garden Route fire prevention plan and surrounding regions not yet attended to. However, then the present situation should financially be changed for Cape Nature, as allocated budgets for some staff increases will have to be provided for.

My proposal will be to let CapeNature take over responsibility for the planning and implementation of the Garden Route's fire prevention region, (a) to select at least one champion for this first, who should be stationed in George (centre of the region) and (b) be trained properly in all planning, mapping and control aspects of the Garden Route regional plan and be exposed to advanced training in this respect. This should include training in the use of fire simulation computer programs, selection and manipulation of satellite images and mapping thereof, as well as training of key staff from District Municipalities involved.

Medium term (once the Garden Route plan has been implemented), this person should extrapolate the regional fire prevention planning and implementation to surrounding regions, but then additional staff might have to be appointed, particularly when extrapolating the "regional idea" to the Western Cape Province Metropole and surrounding land.

Selected training and consultation can still be provided for by myself, but this will be restricted to the Garden Route region, and then as long as my (still good) health permits this. Ad hoc consultation, however, can always be provided by me at any time.

(iii) District Municipalities (Garden Route)

This Municipality will best be suited for the implementation of regional prescribed fire tasks, once trained for such tasks by CapeNature. This will include the use of Working on Fire staff and equipment, and the training of staff and fire bosses for these tasks as trained by CapeNature, by experienced staff (also trained for such courses and practical training).

Selected staff for these new tasks should preferably be selected from the ranks of the District Municipalities and be capable of being trained for these subjects successfully. However, some increase in budgets will have to be provided for to facilitate this.

(iv) Local Municipalities (George, Knysna)

These Municipalities should take over control for improving the Urban Interface fuel management tasks as and when required, as part of their existing staff tasks, subject to inspections by the DAFF local FPO.

19.2 Timetables, task allocations and future program visions

Target date: End Febr 2020:
Book will be available on website at international scale.
Enquiries Neels de Ronde – neels@derondeart.co.za

Target date: End March 2020:
Circulation available book on website

Target date: End April 2020:
Considerations of applications, discussions and decided on the way forward.

May to July 2020:
Considerations and discussions between the different role players, arrangements for budgets and appointments.

Target date: End July 2020:
General meeting for all the regions' role players, to advise all about "the way forward" and changed responsibilities.

August to November 2020:
Selective training and advisory sessions.

Target date: End January 2021:
Start with drawing up of Garden Route fire prevention plan.

Target date Beginning May 2021:
Garden Route fire prevention plan start of implementation.

19.3 The attitude towards the new fire prevention plan for the region

This question the attitude of all people involved in developing, planning, controlling and executing the fire prevention plan, from the top Government officials involved, to the fire bosses and fire fighters applying the fire applications, as well as the local public at large. This will ask for some effective technology transfer and a dedicated will to achieve success, knowing that all earlier measures failed completely!

I know a lot will depend on how many people will read this book, and will agree to full implementation! However, I am also committed to provide at least one illustrated ppt presentation during a fire-related meeting, should I be requested to do this. I have no illusions that the plan – with its new and rather drastic ideas – will meet some opposition. My point of view has been, still is and will always be: ***"THERE ARE NO ALTERNATIVES!"***

Photograph 32. A typical Industrial *Pinus elloittii* plantation interface on the Garden Route plateau with fynbos in the foreground growing in a depression/watershed. Both are approximately 10 years old, leaving both unburned, where the shrubland will form a fire hazard for the plantation as a whole. The solution? Make it fit into a N to S buffer zone, which can then be prescribed burned in three rotations, namely (i) the Pine tree stand in the background (at age 10 years), then (ii) the Pine tree stand in the foreground where the photographer is standing (at age 12 years) and (iii) the more difficult fynbos visible in the foreground (at age 14 years).

However, once my motivation and proof for the vital role of fire in the natural ecology of the region is sinking in, I am positive there will be agreement that fire exclusion spells only disasters and that selective prescribed fire is the only way to go, I am sure there will be general approval. During the past few years the worst fire-related human mortality and structural damage has been experienced where fire exclusion used to be the norm, but this is now drastically changing in worst affected countries, such as Russia, Greece, Portugal Chile and the US (California). I would hate to see the South African Garden Route being added to this “black list” ......

Conclusions:

(a) The most important changes proposed in this chapter are (i) that regional fire prevention plans should be developed, planned, maintained and controlled by the Provincial Regional Authorities and that (ii) the role of Central Government should not be changed a lot and basically revolved around Act 101 of 1998 management and control, (iii) that District Municipalities should be added with the responsibilities of the fire prevention measures regardless property ownership(s), and that (iv) Local Municipalities should take over control of Urban Interface issues, within Urban boundaries.

(b) The timetable provided here is proposed for the Garden Route region, but can provide other countries with some idea how much time will be needed for implementation.

CHAPTER XX

CONSIDERING ADJUSTMENT OF ACT 101 OF 1998

The development, construction and maintenance of the proposed Garden Route plan will have to be "bought" as a basis for fire prevention (fire protection) in South Africa, before this Act is considered for adjustments/amendments.

The fire-related Laws in countries other than South Africa, will require similar adjustments/amendments and this chapter can then act as a guide for similar changes to be approved by all levels of Government.

Act 101 of 1998 is attached as "Appendix A".

20.1 Chapter 1 - Introductory Provisions

At this particular point in time we assume that the following organizations will be affected by these adjustments/amendments as set out under Chapter XIX and this will affect the Act as follows:

- The role of Central Government (and thus of the Fire Protection Associations) will not change, but the Provincial Government (CapeNature) will now be controlling regional fire prevention (regional fire protection, according to the Act), but will still work closely with the local Fire Protection Officer with regard to all Legal matters in relation to fire prevention/protection matters.

- Regional fire prevention structures (from now on in this chapter referred to as "**regional buffer zones**") will now be described under chapter 1(2) of the Act, as well as any related terms.

20.2 Chapter 2 - Fire Protection Associations

- The added duties with regard to regional fire prevention at Provincial or Municipal level will have to be added to the Act as an amendment, after Chapter 2(8).

- The duties of the Fire Protection Officer (Chapter 2(6)) may have to include added responsibilities in relation to all regional fire prevention matters, including Legal matters in this respect.

20.3 Chapter 3 – Fire Danger Rating

- No changes to this Chapter are foreseen at this stage, although the methodology might have to be extended to include improved methods of calculating these ratings.

- The described Fire Hazard Rating system (forming part of the regional fire protection plan) will have to be provided in the Act as "Chapter 3A", as this will also form part of the responsibility of the Provincial Government (CapeNature), with Legal matters in this new system still falling under Central Government (the Local Fire Protection Officers') control.

- The FHR system will form part of the regional fire prevention plan and will thus automatically fall under CapeNature management.

20.4 Chapter 4 – Veldfire Prevention through firebreaks

- The title of this chapter has to change to make provision for the development, planning, construction and maintenance of regional buffer zones, which will not necessarily follow existing firebreaks along property boundaries, but more effective buffer zone routes and meaningful specifications.

- The Act should make provision on the duty for property owners (with or without assistance from District Municipalities) to clear and maintain their portion of such regional buffer zones and can be forced through this Act to do so for the benefit of all.

- Where applicable, such buffer zones can replace outdated firebreaks in consultation with the responsible authorities. If the role of existing firebreaks remains unchanged, the full detail of this chapter will still be applicable.

- Consultation with the regional FPO as well as the local CapeNature representatives should regularly apply regarding all related fire prevention matters.

- Provision will have to be made under this chapter for the relevant responsibility for regional buffer zone tasks as discussed, by Central, Provincial and District Municipalities.

20.5 Chapter 5 – Fire fighting

- The only addition that should be make provision for under this Chapter, will be the added assisting role local CapeNature managers will play, when considering planning and applying counter fires from regional buffer zones, but only in an advisory capacity, as the controlling role of the District Fire Chiefs will remain unchanged.

20.6 Chapter 6 – Administration of Act

- The added responsibility to organisations for regional fire prevention should be added as an amendment to the Act. This must include the role of the Provincial Government regarding the development and planning of regional buffer zones.

- The added responsibility for the assistance for buffer zone construction and maintenance regarding the District Municipalities will have to be included under this chapter of the Act.

- The role and responsibility of fire protection within Urban areas (Urban Interface) will have to be described by the Act under this chapter.

20.7 Chapter 7 – Offences and Penalties

- An amendment will have to be provided under this chapter, to make provision for a situation where the role of external property firebreaks has been taken over by regional buffer zones, and where the responsibility of property owners has thus been changed along certain property boundaries.

- Where a property owner is responsible for some pre-determined work on the construction of his portion of a regional buffer zone, an amendment has to be made under this chapter that this can be enforced by Law.

20.8 Chapter 8 – Enforcement

No amendments or additions foreseen.

20.9 Chapter 9 – General and Transitional Provisions

No amendments or additions foreseen.

10.10 Concluding Notes

Readers from other countries as South Africa will obviously not have to consider changing their Laws in relation to this Act, as I accept that each country will have to consider their own local Laws, and how these will have to change when considering the application of regional fire prevention as set out in this book.

Once readers have gone through this book (in particularly Chapters X to XVII), they should look at the Legal requirements for their region first and see what steps will be required to make the development, planning, construction and maintenance of regional buffer zones, to make this Legally feasible without Laws restricting such efforts. Where there are restrictions by Law making such work impossible, plans will have to be drawn up for amendments and other changes to be submitted to Government for approval, as a matter of urgency.

Where there are problems with fragmented properties, regional buffer zone routes should be considered to avoid such fragmentation, on less fragmented land. Alternatively – where fragmented properties cannot be avoided, continuous lines in the landscape through such numerous properties - such as main rivers, public roads and prominent rocky heights, should be used to form the basis for regional buffer zones, and properties added to this with the least impact without weakening of such buffer zones.

Conclusions

(a) Although I realise that in many countries the Legal implications of regional buffer zone construction and maintenance will result in numerous Legal hurdles, the seriousness of the threats as a result of climate change realities make such harsh decisions absolutely necessary, and this should get full support from such countries' Government. ***There is no other way and time is running out fast, or has already overtaken such disaster events during recent years.***

(b) By starting with countries falling within the Mediterranean Zone-biome, there is no doubt that the steps set out in this book should be applied as a matter of priority, with some acceptable adjustments for custom use necessary and acceptable without losing sight of the ultimate regional fire prevention goals.

CHAPTER XXI

IFP PLAN ADJUSTMENTS AFTER MAJOR WILDFIRES

I am starting here with the "top down approach" again, to wildfire assessment and how to also use this approach and following procedures for determining regional fire prevention adjustments.

I used the problem areas in this case, in this assessment program, in the case of examples experienced of the 2017 and 2018 wildfires, and then also consider what should have been done in the Garden Route region.

21.1 General comments and introduction

Any future adjustments after major wildfires will require editing (or consideration for editing) of Chapters X to XVII, each to lesser or more intensive degree. The degree of changes to the regional fire prevention plan depend on the degree of changes required within or adjacent to the area affected by such a wildfire - and more particular – at what stage of IFP development/application including buffer zones have been affected by the wildfire.

Should such a wildfire occur during the development phase of the IFP plan, such a plan (as proposed in this book) can still be adjusted. This thus refers to any major wildfire that occurs during 2020, in the (now) still unburned area, thus the area excluding the 2017 and 2018 wildfire areas.

Where the fire occurred after the year 2020 (say between 2021 and 2025), this will most probably still occur within the unburned area (thus outside the 2017 and 2018 wildfire areas), and changes in the existing IFP plan can just be concentrated on affected buffer zones. When such wildfires were experienced after 2025, only affected buffers will have to be considered for adjustments, until such time that the whole regional IFP plan has to be revised (most probably not before 2030).

21.2 Modus operandi – IFP adjustments after a new wildfire

Firstly the impact of a mega wildfire has to be assessed in terms of damage to standing timber (Chapter IX) and salvage procedures (in terms of recovering timber to cut timber lost in such a wildfire). Such salvage plans will have to be continuously monitored over time, to check for secondary damage and possible adjustments required in timber exploitation priorities.

Secondly, the impact of the wildfire on physical and chemical soil properties will have to be determined and quantified in terms of soil preparation and nutrition required, on land burned over which is being utilised for agricultural or commercial forestry purposes. Such action plans in terms of crop re-establishment might have to be based on needed repairs of damaged sites be crops are re-planted.

Thirdly, the impact of the wildfire on weeds should be determined and mapped before and after the fire occurred and an anti-weed control program will have to be put into operation as soon as this is applied with optimum effectiveness. When routes of the regional buffer zones are planned, provision should also be made to accommodate any weed control planned for during the buffer zones' construction and maintenance procedures.

Fourthly, the top down approach has to be initiated to determine how a mega wildfire has affected existing regional buffer zone plans. The wildfire area has to be mapped soonest after the wildfire has occurred, and then the regional (main) buffer zones have to be deviated from their original routes as and when required.

Fifthly the working plan has to be adjusted accordingly, as the 2017 and 2018 wildfires have caused a concentration of prescribed fire use on unburned land, until such time that the burned (wildfire) areas are ready to receive their initial prescribed burns (in these examples mainly in fynbos shrubland).

21.3 Using lessons learned about a new wildfire for IFP adjustments

Here I will again be referring to Chapters X to XVII of this book as the procedures are here provided in the order in which they should be attended to: In the case of a new regional plan as a whole, and in the case of adjustments after a mega wildfire, focussing on the wildfire area as well as its immediate surrounds.

Where the wildfire occurred in region where an existing plan was already in operation (or in the process of completion) it is equally important that some critical questions are being raised in relation to the effectiveness of the fire prevention plan, such as:

- Did the wildfire breach external (main) buffer zones, or was the fire ignited internally, within the regional area?

- Identify where and which zones/firebreaks were crossed by the wildfire. Were these adequately prepared (fuel managed) or is there room for improvement? What improved measures will be required to prevent a re-occurrence of such a wildfire?

- Did the wildfire cross fire prevention lines as a result of fuel not being managed as planned because of some delays? If so, why?

- Will it be necessary to further reduce the internal "area at risk"?

- Should the route originally selected for a buffer zone that was crossed by the fire, be re-considered and/or routes changed?

- Should fuel reduction measures other than the preparation of buffer zones having been attended to? Are there more of such “hot-spots” presenting a threat to fire hazard in the region? What regional directives should be considered to reduce such threats?

- Any other fire prevention shortcomings we should take note of?

- Any Legal follow-up required?

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21.4 Notes about the action programme after the 2017 and 2018 wildfires

The biggest problem I have seen in this region is that no dedicated top-down assessment was conducted after these two very serious wildfires, and this is still the *status quo* 2-3 years thereafter. No regional attempts were made to make some drastic plans to for regional fire prevention zones in the affected area and unburned surrounds, as was confirmed by a few very commendable prescribed burns that were applied during 2019, which were just some individual attempts and not part of any regional plans. These were just creations of “prescribed burning islands” which will have no effect on future wildfire events to come.

The problem is thus that no concerted efforts have been made to realistically assess what fire prevention measures will be required to make a difference in containing future wildfires, *regardless what problems may exist to do so!* I am afraid that the Garden Route region is still attempting to attend to ad hoc prescribed burning requirements, just falling into the same pitfalls existing in the region, simply closing their eyes for what is really required.

South Africa is not alone in this serious shortfall at regional level, and today we see similar problems cropping up in Australia, Chile, California and southern European countries. Still, politicians are advocating “solutions” around such problem areas, failing even to considered doubling or even tripling regional fire prevention attempts, let alone try to plan such finance cleverly as I explained in this book. The will is simply not there right at the top of Governments, because these people are continued to be too scared to lose their seats.

However, the public at large is now standing up to protest such failure to act, as is happening right now at the time of writing, in Australia, following closely in the footsteps of California (USA). The biggest problem is that time is still ticking over, and the longer we wait for some drastic action, the more difficult this becomes.

Will the public accept that large scale prescribed burning will have some calculated risks, and can controlled fire be used to addressed with the correct training and education of the public? I am sure they do, if such calculated risks are necessary to stop future wildfires and wildfire damage. Every country has some experienced fire fighters that can successfully meet such challenges, with maybe some “tuning up” with advanced fire-use training. Is no-one prepared to stick his/her neck out and take the lead in such concerted action?

To summarise:

(a) Please dear readers, assist me bringing this message home to the people that CAN MAKE A DIFFERENCE at global level. I can only present my feelings in this book, but cannot continue this "fight" alone any longer. I am not getting younger!!!

(b) As I am writing this, it is Christmas day, 2019, and let this then also be my Christmas wish!!!!!!!!!!!!

CHAPTER XXII

INTEGRATION WITH URBAN INTERFACE PROGRAMS

In the case of the Garden Route wildfire history, the most serious Urban Interface shortcomings were experienced with the 2017 Knysna wildfire, and the reasons for this will be discussed under this chapter as well as solutions for the future. In the Knysna heights townships, extremely old (senescent) fynbos was allowed to grow right up to walls of most homesteads for periods up to (and more than) 50 years.

In the case of Knysna, the most serious threatening vegetation was burned away during the 2017 wildfire, and this fuel free status has to be maintained, even by Law if no voluntary efforts are made to reduce fuels accordingly around homesteads, and this should apply to all Urban Interface problem areas around the globe.

It is also recommended that local Municipalities should be fully responsible for the maintenance of such fuel reduction Laws, up to the external firebreaks of such townships, which are in turn structured and maintained by the District Municipalities.

22.1 The creation and maintenance of external firebreaks at Municipal boundaries or other adjusted firebreak lines

I would like to discuss under this heading, the rural and urban situation in the Knysna area, before and after the 2017 wildfire, when so many homesteads were burned out within the Knysna heights area.

Firstly, there is indeed a whole range of natural protection against fire around Knysna that has to be considered, also for future measures to reduce the hazard of the Knysna Urban Interface there. SW and S of the city centre, there is the Knysna lagoon providing very effective natural protection, as was proved during 2017 when it kept the wildfires coming from Brenton on sea, Brenton on Lake and from Belvedere out of the Knysna main city and surrounds. The only minor provision to be made along this line will be a minor firebreak along the N2 from where it crosses the Knysna lagoon, to as far as its entrance into Knysna town.

Secondly, the Knysna river W of Knysna could have provided adequate fire protection along this line, but it failed to do so, because no effective fuel management measures were taken along its riversides inside the “jungles” growing there. This dense vegetation present there before the 2017 fire, made it possible for this wildfire (coming from the Rheenendal area) to spot and spread across the Knysna river, then spreading uphill to the top of the Knysna townships and into the adjoining Urban Interface, and from there, spreading in a general E direction into the Kruisfontein MTO plantation.Then - after burning houses within the informal/formal settlements there as well - eventually entering Knysna Urban areas from a NW, N and NE direction.

Thirdly, no fire prevention measures were in place along the N Rural/Urban Interface, which could then again have stopped the fire threat from that direction. Existing mainly of fynbos and industrial Pine plantations, the situation aong its N areas will have to be watched carefully, as here this line is directly exposed from the dangerous Bergwind conditions from that direction, particularly along the road situated there along the higer areas there, forming a perfect buffer between the rural and Urban Interfaces. Photograph 14 illustrates this situation clearly, after the 2017 wildfire.

Fourthly, the fire entered the Kruisfontein industrial plantation E of Knysna, after spotting into these Pine plantations from the W/NW, the fire spreading from here, damaging a significant portion of the plantations there near the forest station as illustrated on Photograph 7. The firebreak between this plantation and the informal settlements W of this area, was not adequate to keep the fire out of this plantation, and future improved fire prevention measures, in the form of a buffer zone along this interface, will be the only answer to solve this problem soonest along this flank.

Fifthly, the ignition of the wildfire SE of Knysna from one or more ignition points has not yet been properly investigated and explained (see Photograph 14). However, it is clear that a regional buffer zone will have to be created along the Kruisfontein to Knoetze road – using this road as a base route for a buffer zone – to avoid future damage as was experienced then, inside the S portion of Kruisfontein, Harkerville and eventually Plettenberg Bay, where extensive damage was experienced to homesteads and other properties.

To summarise, it is thus clear that E and SE of Knysna, the wildfires indeed entered the rural land from the Urban township areas, and not vice versa. It is also clear that at least the fire coming from the N of Knysna, was the cause of this fire eventually escaping into the rural land into the direction of the Plettenberg area.

22.2 Joint responsibilities between the District and Local Municipalities re fire prevention lines between them.

Where the responsibility for joined Municipal firebreaks/buffer zones has to be considered, the organisation responsible for its regional structuring, treatment and maintenance (in this case CapeNature staff) has to consult with both the responsible District and Local Municipalities, to determine all firebreaks/buffer zone routes and specifications, preliminary prescribed burning dates (and other fuel management treatments), before the regional plans (and Municipal working plans) are drawn up. This includes deciding about optimum route options and which Municipality will be responsible for what action. This process will also include meetings with responsible rate payers and other home owners involved.

This planning process will also include the calculation of required dimensions of firebreaks (to be conducted by the regional fire prevention officer from CapeNature in this case) and consultation about this with Municipal officials. The Municipal officials will also require a copy of the region fire prevention plan as well as detailed directives for specific firebreak preparations.

22.3 Notes about fuel management within Urban Interface areas

A local Municipal plan – with directive and rules for home owners – has to be drawn up and made available to property owners of the Municipality concerned (in this case of Knysna), with maps pointing out where Municipal responsibility exists on municipal properties, regarding fuel reduction measures.

In the case of each individual Municipality, specific notes will have to be made about the natural vegetation growing within Urban areas, and how these should be controlled. In the case of Knysna this will be in particular fynbos, with specific instructions which are the owner's responsibility and which tasks (fuel reduction) will have to be conducted by the Municipality. Alternative vegetation for fynbos cover (such as lawns, vegetables or evergreen garden shrubs) will then also be recommended.

Conclusions:

(a) Within each Urban area, the Municipality responsible will have to take over control of all Urban Interface problem areas in the form of fuel management programs.

(b) The control over Municipal boundary fire prevention measures will be the joint responsibility of Local and District Municipalities, while the planning, mapping and regional control will be the responsibility (in the case of the Garden Route region) of the Provincial Government, in the case of the Western Cape Province, this will be CapeNature.

CHAPTER XXIII

WHY DRASTIC ACTION IS REQUIRED TO MEET FUTURE INCREASES IN WILDFIRES

It is important that we take note of the realities for fire prevention requirements, considering the present "time-bomb for disaster" in the Cape Regions of South Africa, as well as around the globe within all Mediterranean Zone-biomes and related climatic regions. The combined effects of the lack of fuel management and climate change have (particularly during the past five years) been hitting home the raw reality of the gravity of the extreme disaster status everywhere within these regions: THERE IS SIMPLY NO TIME TO WASTE!

The reality of costs in human lives and properties today runs worldwide into trillions of Dollars/Euros, while the same amounts are most probably already spent on fire fighting costs, which are absolutely useless when it really counts. Can at least a portion of these astronomical amounts not be spent on where it really counts: Improving or fire prevention systems????

After a mega-wildfire was experienced, all are shocked, blaming the authorities in not doing enough, but most are missing the reality of fire dependence of the natural vegetation and the desperate need for increased prescribed fire-use for ecological as well as fuel management reasons. However, within one or two years, the urgency for all this is forgotten by the public at large and the authorities still do not see the urgency for drastic action. Back to square one..........

23.1 1970 to 2000: From common block burning in fynbos to fire exclusion

Fynbos – the most prominent natural vegetation of the Garden Route region in South Africa – was for decades before 1970 prescribed burned in blocks in the Outeniqua and Tsitsikamma Mountains. During the years 1970 to 1980 management of these mountains was handed over from the Department of Forestry to the Cape Provincial Administration (CapeNature) with all staff, including the management foresters responsible for the fynbos prescribed burning programme.

Although the prescribed burning was not everywhere perfect (e.g. around Cradock Peak in the Outeniquas there as already before 1970 a backlog in the burning program), the rest of this Mountain range – as well as the Tsitsikamma Mountains – were burned with a near-perfect burning mosaic, which I can remember, as my forestry career started in the region during 1962. Thereafter fynbos block burns reduced steadily in area burned as well as numbers of burn applied.

The change in controlling organisation, from the Dept. of Forestry to Provincial Administration (CapeNature), might have triggered this sad state of affairs as the experienced managers reached retirement age and were steadily replaced with young managers not properly trained in prescribed burning application. A significant reduction in finance added to this problem as the areas these managers had to control increased, causing a decreasing lack of resources, which had to take its toll.

However, I have full confidence that the remaining top management of CapeNature will be the best fitted organisation to bring back the effective (ecologically-required) prescribed burning programme, provided top management will not only support this added responsibility, but will also provide the required staff numbers, training and finance to make this process possible.

23.2 With such an increased area burned over by wildfire recently: Now is the time

Starting with the Garden Route region, the recent Knysna and Outeniqua wildfires provide a total area exceeding 130 000 ha which cannot be considered for prescribed burning exposure before the year 2030, and which provides thus a perfect "window" to attend to the backlog of prescribed burning in the unburned vegetation of this region, as there are numerous "hot-spot" sites within this sub-region, requiring fire urgently. This, provided there is a regional master fire prevention plan in force (planned, improved and operational). With a set detailed plan of action whereby prescribed burning has to be applied according to a strict priority list.

The sooner the revised prescribed burning programme can come into operation the better. The area lost in the 2017 and 2018 fires was huge, but more regional sites are still carrying extremely old vegetation and (i) have to be isolated for safety purposes and (ii) then controlled burned under optimum weather conditions, but only once the "isolation measures" have been completed.

The situation becomes even more urgent, as fuel accumulation continues at a threatening rate, together with extreme weather conditions setting in as climate change is steadily increasing fire hazards. After the Garden Route wildfires, more serious mega-wildfires are "burning the news" around the world, and right now e.g. the Australian State of New South Wales lost more land to wildfires than the total of Belgium, and it is still burning!

As we are watching, the size of mega-wildfires is growing exponentially, while the world is looking on helplessly, particularly where the use of fire was exchanged for fire exclusion. Now everyone is blaming everyone, but mostly the Governments responsible for wildfire control, and quite rightly so as many of them were fully aware of how the problems could be solved, but decided to not consider fire-use, because that could harm their parliament seating, because this would be most unpopular under the public at large. However "John public" is now fast learning to realise the reality of the effects of "fire exclusion policies" and it will not surprise me if Governments could topple as a result, sooner rather than later.

23.3 The reality of the Garden Route disaster

Meeting the challenge of acceptance of reality:

This is the most pressing urgency of the situation, as the public at large, the role players, decision-makers and authorities simply cannot get to grips with the gravity of the 2017/18 mega-disaster that hit the Garden Route. “What has gone wrong?”

The attitude of all living in the Garden Route region as well as authorities, will have to change their approach to wildfires drastically, and this is the issue that worries me most of all: The negative attitude of most of them with regard to the increased fire problems they are faced with! In Australia the people are close to “throwing their hands in the air” and to just “give up” on the wildfire impacts: The attitude of “whatever! We can do nothing to fight this threat effectively, not even make a dent in this “rolling fire monster!”

So, once we have changed the attitude of all to become more positive and accept that “yes we can make a difference”, we can sit around a table a spell out the solutions for these negative set of problems we will be on our way to achievements! All these mountains of negative ideas about “shortage of finance”, “lack of manpower”, lack of training”, “restricting Acts”, “lack of will by the public” and many more, can be overcome, provided we get strong leadership to do so. Some decades ago we used to have famous international scientists in South Africa who sorted out the fire-ecological problems in the path of effective fire-use, ahead of all other countries, and we had the fire managers who had the experience and the guts to apply the controlled fires “as and when required.” Where have they all gone? Have we now entered the stage of unmotivated softies?

Wake up the potential leaders

In South Africa we have the leaders to steer our fire management leadership back on course, I am sure and positive about that! Give the key staff the right incentives in the form of official “blessing” and “believe” in the way forward and to meet the wildfire challenges head-on. In South Africa we do still have some very experienced fire managers, which are the best you can get in this world, and we still have a core of young scientists who can steer a fire-use program “with a difference” to success and support for our fire management.

I have full confidence in my fellow-South Africans to show the world that – with the correct use of fire – we can meet the growing wildfire problem with confidence, and success! My legs cannot carry me on this course any longer, otherwise I would have been there with my colleagues, but at least I can share what I have achieved during my working career, otherwise I have to take it all into my grave: This is indeed my greatest scare.

We are not alone in this world

What has happened in the Cape Regions in South Africa has been happening in all Mediterranean Zone-biome regions around the globe. It happened in Southern Europe, California, Chile, South Africa as well as W and S Australia, as has happened in some bordering countries to this Zone-biome, such as in NSW (Australia), some of the other American States, some bordering countries in Europe and others. Yes, in some of these countries there are experienced fire managers and scientists, but their stories are mostly one of resistance against fire-use, and those are indeed the "kingpins" for a successful prescribed burning programme. There are also a few dedicated scientists supporting its fire managers, particularly in the USA and European countries, but unfortunately there are also some negative scientists "breaking-down" the support for effective fire-use. What I said earlier about the "negative attitudes" is thus also applicable to these countries. However, the core of these key-managers and scientists are working hard on improving the use of controlled burning, and I hope that this book can assist them in their dedicated work. Good luck to all my dedicated friends and colleagues!

Starting from the top: How can we win the votes from the politicians?

I hope there are some of the readers who know the answer to this tricky problem! However, I will think about the best way to do this from my side, and for a start I would like to ensure that the top decision-makers get a copy of this book. Otherwise, I am working hard on the best outlet for this book the message reaching all interesting readers as far as is possible to all interested in this topic.

The best voices in favour of the use of prescribed fire, should of course come from the public at large, but unfortunately this potential support group is mostly ill-informed, and such a move cannot be expected from them. It is, however, interesting to take note of how the Australian prime minister and Government in general are receiving loud resistance about the way the wildfire problem in this country is met. However, this is more in terms of the lack of urgency from some politician (or so I heard) than fuel management, but I hope this will be the next question coming once the fires are "out", namely the longer-term solutions.

The plight of our fire fighters

There should not be any question about this: Those guys are doing an amazing job in saving human lives and properties! However, in terms of making a dent in the area burned over, the success rate is unfortunately small, even with the largest of bombers around and numerous buckets of water being applied. Their efforts in saving lives and homesteads in their aerial bombing attempts, is fantastic in the light of all odds.

When these forces (at least the permanent staff) is not fighting fire during the dangerous seasons, however, I would like to see them also being used for assistance in the application of prescribed burning programmes, when these programmes become an approved reality.

Photograph 33. Fire fighters in action containing a wildfire in plantation slash (source: An unknown photographer).

Why am I still positive about the "regional fire-use solution" against wildfires?

Simply because what is right is right and not wrong! If our fire-ecological studies have proved that a vegetation community requires fire for the maintenance of biodiversity, then that will be the way to go. To work against nature can never be correct (like in fynbos shrubland), whatever way we look at this thorny issue.

OK, so in man-made ecosystems (such as in Industrial Pine plantations) we may have to compromise the use of fire because at the end of the day we still want to produce timber economically, but our research has here shown that we can still benefit from the correct use of fire and simultaneously reap the ecological advantages. We do not have to re-invent the wheel to get to such an optimum compromise! All we now have to do is fit such burning into a region master fire prevention plan and we can make feasible forestry operations also in this region sustainable and profitable.

Also, regarding our fynbos shrublands, block-burning has to be brought back into our fire management plans. This has to be applied in such a sequence to fit the construction of regional buffer zones, the correct burning frequency, burning season and optimum fire intensity, but all combined we can satisfy fire ecological requirements as well as fire prevention needs combined, that is a proven fact!

We have the manpower, experience and will to complete such a master plan, in whatever region, so ***WHAT ARE YOU ALL OUT THERE WAITING FOR? DO NOT WAIT FOR THE NEXT MEGA-FIRE TO WIPE OUT WHOLE REGIONS FROM WHICH IT WILL TAKE A LONG TIME TO RECOVER, IF AT ALL IN OUR LIFETIME!***

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