Systemic Risk and Portugal's Forest Fire Defense Strategy

An Assessment of
Wildfire Management and Response Capability

A Report Submitted to Grupo PortucelSoporcel

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Executive Summary

Between 30 July and 3 August 2003, 80 fires burned more than 220,000 hectares in mainland Portugal. Within that same period on 2 August, 2003, 36 fires burned more than 90,000 hectares in a single day! Prior to 2003, that was the average burned area for an entire year. A record heat wave had a grip on most of Europe. At the time, this rare situation was considered a weather anomaly, something that might only happen once in a century.

Then in 2005, it happened again. A record high number of ignitions during a summer plagued by insistent drought resulted in an excessively large burned area. Twice in three years is not an anomaly. In fact, many meteorologists and climate researchers are now looking at the most recent decade as a new normal; a new baseline of weather and climate statistics from which to view the future. Could it happen again, and if so - more importantly, when?

This review, commission by **Grupo PortucelSoporcel,** examines future levels of systemic risk in Portugal's forest fire defense and management capability by assessing first the potential for future extreme fire years or worse per what occurred in 2003 and 2005. Fire researchers in Portugal have been studying this problem assessing fire activity and its severity extensively from a number of perspectives. The general consensus is that Portugal is experiencing much greater total forest fire activity and a greater frequency of larger wildfires. This review reaffirms three main conclusions about future wildfire risk that can be derived from the analysis and studies conducted in Portugal in this decade:

1. The risk of an extreme fire year (over 250,000 ha. i.e. 2003 & 2005) continues to increase.

2. The incidence of large fires (>100 ha) is increasing for summers with average to severe burning conditions.

3. The frequency of concurrent multiple large fires and high numbers of fire occurrences is likely to increase in even normal fire years and certainly be a major issue for extreme fire years.

A second part of the review looks at the changes made in Portugal's fire defense framework and resource levels following major system changes made as a result of the 2003 & 2005 fire years. While structural fuel treatment planning and implementation skills have improved and the core of a viable structural defense program has been established, fuels continue to be added much faster than they're being removed. Extensive burned areas from 2003 and 2005 are now ready to burn again with little management of forests outside of pulp company control. Although legal mechanisms have been put in place to organize small landowners to take effective, collective DFCI action, most ZIFs are still in planning stages and not yet functioning as needed. A coordinated structural prevention effort over large landscapes by multiple small plot landowners continues to be rare.

This review also confirms that great improvements have been made in operational readiness, National and District level interagency coordination, and fire incident command and control. However, the continued toleration of more than one commander for a fire and the lack of tactical airspace coordination when using multiple types of aircraft on fires, both increase the potential for system failure.

The jury is still out on the effectiveness of the new SIRESP communications system until fully deployed in 2010.

The final part of the review called for a review of system performance effectiveness through on-site field visits during the peak fire season this year. While fire activity was not high and did not tax the system dramatically, this report offers some comments on functionality and operating efficiency. Surveillance, first intervention and initial attack are aggressive and highly effective when fires are quickly detected and accurate locations are reported. However, major deficiencies still exist in the detection system, particularly in management of the RVPV towers. Slow detection and imprecise reporting of fire location significantly reduces initial attack success. Fire cause and criminal evidence is often disturbed by the first arriving fire brigades resulting in a low probability of accurate cause determination, identifying motives and the apprehension of suspects.

The system has greatly increased aerial capability for continued assault on extended attack fires. However, this can far exceed the capability of firefighters on the ground to make effective use of the water drops. The construction of firelines, other than by using existing roads, is still relatively rare. This deficiency contributes to an unacceptably high percentage of rekindles.

System improvements are evident but may not be of sufficient significance to alter the burned area outcome when **above average to extreme** burning conditions exist. The result is that in 1 out of every 4 years on average, Portugal will be at risk of suffering significant forest fire losses. Portugal's forest fire defence system needs to ensure that it has adequate strategic planning and risk management processes in place to be able to handle the increasing probability of extreme and ultra-extreme fire years. To accomplish this, the report concludes, Portugal must focus additional attention and investment on the system areas below.

- **More Strategic Fire System Planning and Risk Management**
- **Enhanced Fire Prevention – both in the Reduction of Occurrences and Increased Structural Fuel Treatments**
- **Stronger Tactical Fire Suppression - Coordination and Accountability**
- **Enhanced Training & Development Investments**
- **New Investments in Evaluation and Research**

Specific recommendations for each area will be found in the 4th section of the Report. In conclusion, this report urges that there is no room for complacency. As far as the system has come since the catastrophic fire years of 2003 & 2005, there is still further to go. Portugal must especially use whatever calm fire years it experiences to best advantage in moving forward.

Report Overview

This report seeks to analyze the current state of Portugal's national wild fire protection system in light of increased resource levels and improvements made since 2005. The review aims to compare emerging levels of wildfire risk dues to changing climate and land conditions with Portugal's fire protection system capability and to assess how the system has operated to date.

The report is divided into three parts. Part I analyzes the fire history in Portugal with an emphasis on the current decade. It evaluates three significant characteristics of Portugal's Fire experience:

- High inter-annual variability between fire years and how this "non-pattern" resembles asymmetric fire conditions,
- Rising incidence of large fires (over 100 ha) and probability of large fires occurring on multiple fronts in different geographic areas,
- Impact of multiple large fires and fire occurrence frequency resulting in concurrent demand for fire response

Completing these assessments is a two-fold examination of driving forces and contributing factors that are impacting fire risk and a look into recent fire research work on climate change and how it is altering Portugal's forests and landscapes. A summary risk table portrays future scenarios ranging from a very benign fire year with under 75,000 hectares impacted to more extreme fire years of over 250,000 ha or a climate change induced worst case scenario of a fire year of over 500,000 ha and weighs historical and future probabilities and impacts.

Part II of the report examines fire defense capability and systems improvements since the major re-organization of national fire resources in 2005/2006. This section focuses on command and control, first intervention and amplified combat capability, i.e. the system resources currently in place. It also examines suppression strategy, tactics, planning, and prevention efforts to determine how well the fire management integrates various response phases and coordination of different stakeholders in fire management.

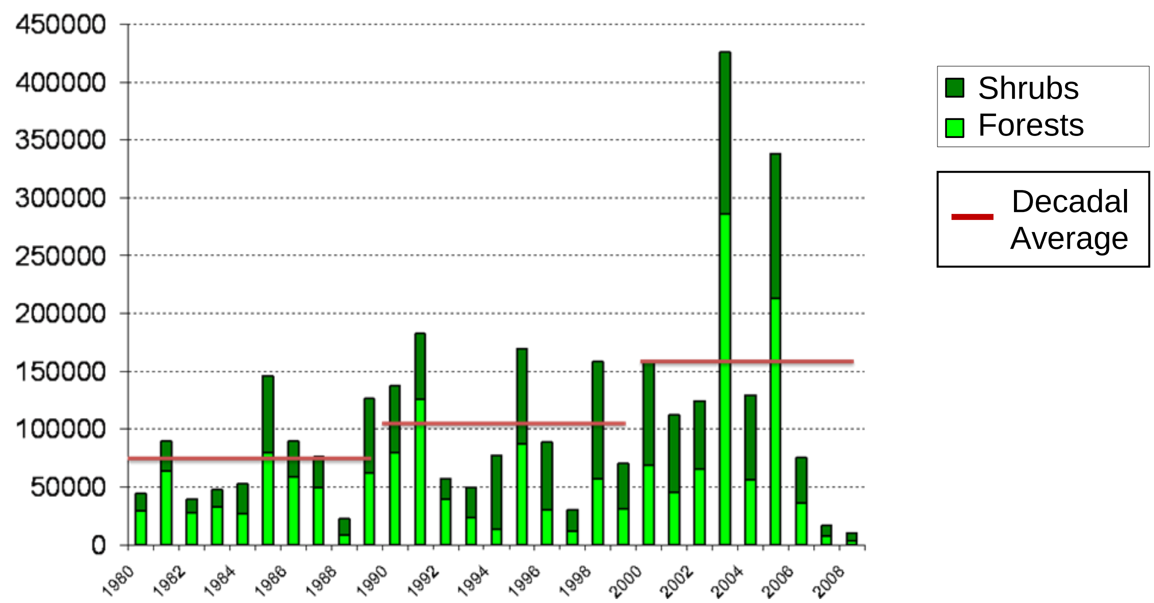
Part III is an operational evaluation of how the system is working. It compares actual fire demand to the now enhanced supply and functionality of fire combat resources in the system. The assessment considers both abilities and obstacles to successful implementation of the Defense of Forests against Fire efforts and how well they meet national objectives. A final section (Part IV) includes conclusions drawn from data analysis, interviews, and operational field reviews. From these conclusions, recommendations have been offered that provide additional ideas for system improvements.

I Assessing Wildfire Risk

This analysis is designed to review risk by first examining wildfire occurrence and intensity since 2000, when wildfire levels rose to unprecedented levels – notably the catastrophic fire years of 2003 and 2005. The threat of wildfire is especially pronounced in Portugal which has one of the highest fire risk incidences rankings in the European continent. This is further confirmed by other studies showing Portugal with the highest average number of fires in the Mediterranean region from 2000-2006 and highest average burned area – despite Portugal's having relatively the smallest total amount of forest land estimated at 3.3 million ha (Goldhammer & Krause, 2008) (Bassi and Kettunen, 2007). Additionally, large fires and their impacts have also increased. A recent report by the European Forest Institute concluded that on average of the over 500,000 ha of forests that burn each year in the five Mediterranean countries, over 75% of the burned area results from the under 3% of the total number of fires (Birot, 2009).

Fire researchers in Portugal have been studying this problem for decades assessing fire activity and its severity extensively from a number of perspectives – fire behavior, population patterns, spatial distributions, land cover, climate factors, and weather conditions among others. Leading fire researchers all point to the same phenomena driven by a combination of contributing geo-economic factors: shifting demographics with population moving from rural to urban areas, changes in land use with more agricultural and forested areas being unattended and not maintained, and fragmentation of land ownership patterns that disincentive investment in forest management and fire planning.   There is general consensus that Portugal is experiencing much greater total forest fire activity and greater frequency of larger wildfires as depicted below.

Figure 1 – Annual Wildfire Burned Area in Portugal – 1980-2008

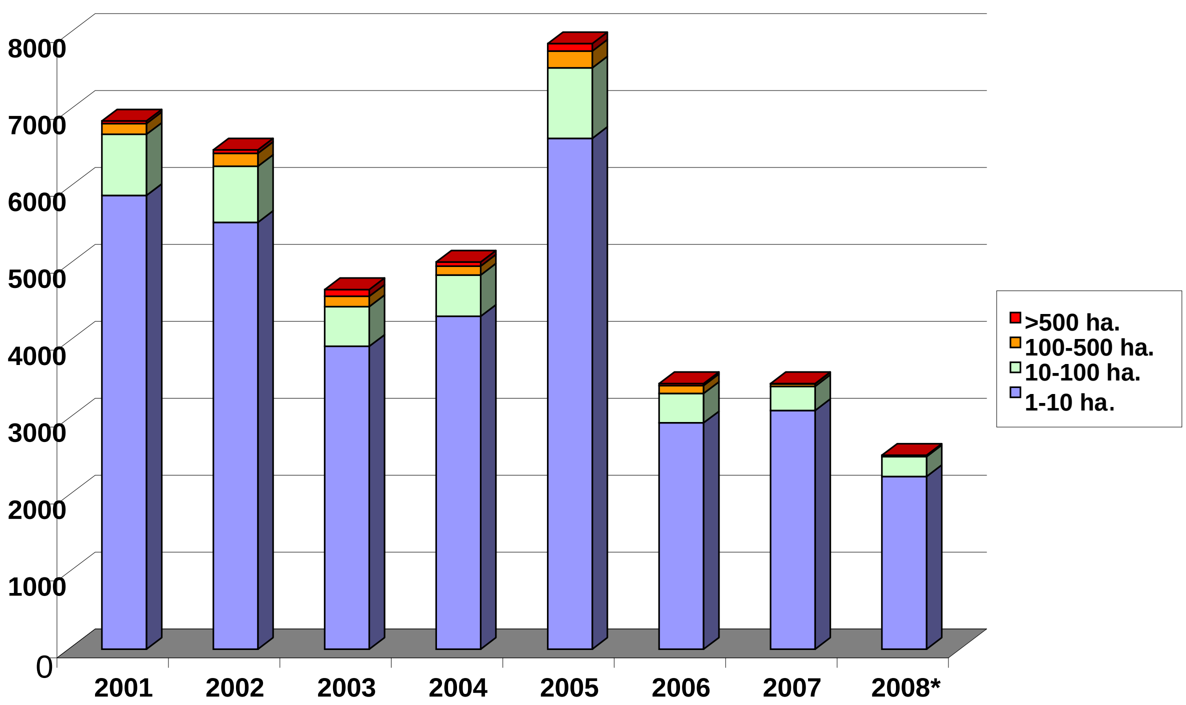


Source: Avaliação do DICIF: Prevenção dos incêndios florestais 2008, Autoridade Florestal Nacional, 21 Outubro, 2008.

One need only examine the trend showing annual burned area totals for the last 30 years to confirm a new level in fire activity in Portugal. A standard metric, the ten year moving average, has increased from under 75,000 ha during the 1980's to 102,000 ha during the 1990's to over 156,000 ha since 2000. Another view would be, whereas between 1980 and 1999, there were six years in 20 where area burned exceeded 100,000 ha, since 2000, six out of nine years exceeded the 100,000 ha level. In risk terms; a 0.30 probability that a severe fire year will occur has increased to a 0.67 chance in this decade.

A similar trend can be seen in large wild fire activity. As Viegas et al note; Portugal had 28 fires from 2003 to 2007 that were over 5000 hectares compared to less than 5 such fires in a ten year period from 1993-2002 (Viegas, 2008). They further warn that while the 2003 and 2005 fire years represent "*… the two worst in the existing record of fire history in Portugal—they shouldn't be regarded as anomalies. In fact, this decade may represent a new period where "natural conditions seem to be changing and having a larger variability*". This is also being felt both in terms of duration of fire seasons and geographic range. Fire conditions – which may have once been viewed as a somewhat normally shaped distribution of fires with the heaviest emphasis in the summer months in traditional fire areas is changing to a new patterns – with different duration periods affecting different territories (Viegas, 2008).

Figure 2 Portugal Fires Over 1 ha - 2001-2008



Based on summary data extracted from 2009 National Annual Operating Plan (see Table 1 below) Figure 2 shows the current decade in more detail. Both Figures (area burned and numbers of large fires) show how dynamic the current decade has become in terms of fire behavior.

Table 1 Evolution of the number of fires, with areas larger than one hectare, by burned area class

Fire Size Categories	2001	2002	2003	2004	2005	2006	2007	2008*
All Fire Occurrences	24.308	26.416	26.059	20.884	35.195	19.731	11.161	11.914
1-10 ha	5.900 85.9%	5.549 85.5%	3.938 84.2%	4.329 86.0%	6.642 84.4%	2.943 85.2%	3.103 89.8%	2.277 89.1%
10-100 ha	794 11.6%	730 11.2%	516 11.0%	536 10.6%	914 11.6%	383 11.1%	315 9.1%	259 10.1%
100-500 ha	140 2.0%	168 2.6%	134 2.9%	115 2.3%	220 2.8%	102 3.0%	30 .9%	17 .7%
>=500 ha	34 0.5%	45 0.7%	88 1.9%	53 1.1%	98 1.2%	25 0.7%	6 0.2%	2 0.1%
Total	6.868 100%	6.492 100%	4.676 100%	5.033 100%	7.874 100%	3.453 100%	3.454 100%	2.555 100%

Source: Relatório Defesa da Floresta Contra Incêndios – 2007 GRF & Relatório Áreas ardidas e Ocorrências – 2008, AFN.

It is the issue of "*large inter-annual variability*" that is potentially the most difficult characteristic to evaluate. A much greater range of variation in burning conditions that can be expected into the future as demonstrated by the wide variation in climate and weather episodes experienced in Portugal during the summers of 2003 (record heat), 2005 (record drought) and 2007 and 2008 (cool and wet). Calado et al also recognized this developing phenomenon affirming in an historical assessment over the last 30 years that for Portugal the positive trend in burnt area since the 1980's also demonstrates a pattern of "*large inter-annual variability" (*Calado et al., 2008).

Wildfire Risk under Asymmetric Fire Conditions

Pereira et al. have described this highly variable annual burn area pattern as *"the asymmetric nature of fire size distribution" (*Pereira, 2004). This pattern of alternating years of "higher highs" (e.g. 2003 for area and 2005 for occurrence) and "lower lows" (e.g. 2007 for occurrence and 2008 for area) can place extreme stress on environmental systems and represents an increasing challenge for fire protection organizations.

The use of "*asymmetric*" as a descriptor for the emerging wildfire environment is generating interest in other quarters. Earlier this year, the US federal wildfire agencies in their 2nd quadrennial fire review explored future fire management strategies under asymmetric conditions. This is of course a somewhat qualitative construct but is worth further exploration and assessment. Appendix A to this report compares Portugal's current fire decade with its California counterparts to provide a more detailed review. Also in this appendix are more graphs and analysis of emerging trends in concurrent fire activity; both in the numbers of days when there are multiple large fires and large numbers of fire starts, as well as graphical comparison of fires in the multiple geographic regions. This information could be useful in positioning fire fighting assets.

Factors Contributing to Increasing Fire Risk

Projective thinking in risk management requires inserting into the assessment an even more extreme fire season (worst case scenario) in terms of where the environment might be over the next decade. As dramatically difficult as the last eight years have been, there is an added probability that the worst years (2003 & 2005) could be exceeded. While this scenario falls short of actively forecasting the incidence of over 500,000 ha fire seasons, the impacts of any of higher climate scenarios (CE-MCC, 2007), where mean temperature increase reaching 7 degrees C by the end of the century, would prevail.

Fire research has already been exploring these factors which might best be characterized as driving forces in the new fire environment. Quantitatively, while the fire numbers are significant in and of themselves in terms of total hectares burned and the frequency of larger wildfires, fire risk is likely to be compounded by these factors which are described and assessed in the subsections that follow. The effects of climate change, fuels accumulation, and fire cause must be incorporated into the risk estimation calculations

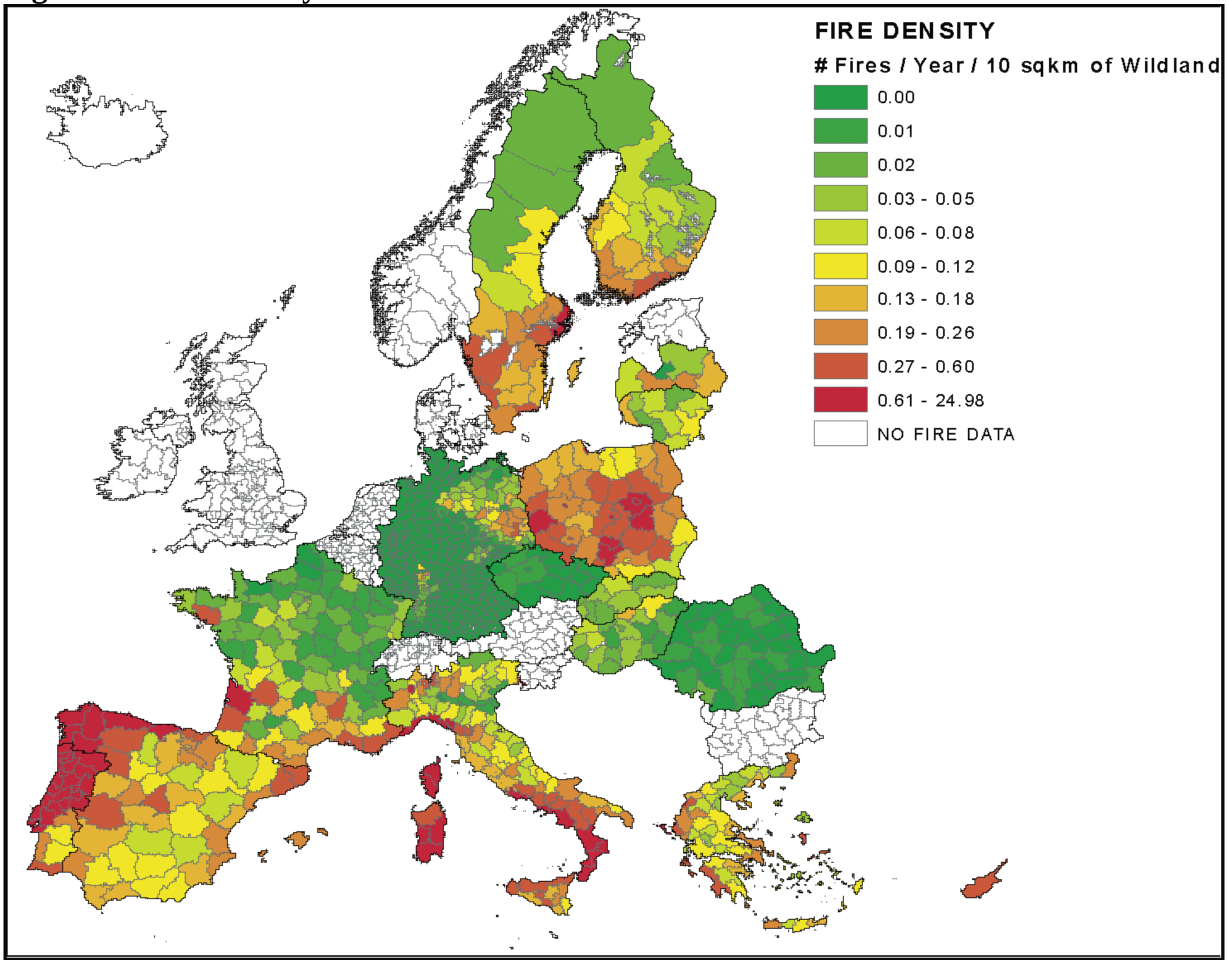
Climate Change and Effects on Fire Occurrence, Severity and Burned Area

Climate studies now show a disturbing trend, particularly for Portugal and other southern European countries. Recent work by Moreno as part of the European Forestry Institute's larger study of wildfire issues projects that temperature levels (especially in summer) in Portugal will be hotter and precipitation levels lower than average (Moreno, 2009). The rising increase in temperatures is now firmly established as a trend and showing no signs of abating in the near future. In 2002, researchers were confirming significant increases ("steep" was used an adjective) in the minimum and maximum temperatures for the Iberian Peninsula (Miranda 2002). Shortly after, research was characterizing the increase – as a European Climate Assessment noted in 2004 as "extreme" (Pereira, 2004). More importantly, this trend was particularly noticeable in Spain and Portugal.

The Government of Portugal has officially recognized the occurrence of global climate change, particularly the effects that are most influential on increasing the risk for large destructive forest fires. In their offical reports, they have projected for this century a "significant" rise in mean temeprature across all regions of Portugal. They also forecast more and more intense heat waves (DGRF, 2007). There is also recognition that these major changes in climate and seasonal weather patterns will place additional environmental stress on vegetation which, in turn, would spur an increasingly severe, new generation of larger, more damaging wildfires. As Moreno has concluded in the European Forestry Instutute study, in these landscapes which are already increasingly vulnerable to fire risk due to combined bio-mass stress and declining agricultural management: "*…Climate change will very likely increase the length and severity of the fire season, as well as the extension of areas of risk. Extreme conditions are likely to increase in many areas and with it, the probability of large fires*" (Moreno, 2009 p 72).

Research by European Parliament's Committee on the Environment has already sounded a dire warning for Portugal – confirming the significant increase in fire activity in the last decade and using a fire density metric (see Figure 3) shows Portugal's high ranking in fire incidence (San-Miguel & Camia, 2009).

Figure 3 – Fire Density in the EU – 2008



Source: EFI Discussion Paper 15, 2009, Living With Wildfires: What Science Can Tell Us?

While research continues to note the contributing factors to the increase in burned area, and fire density, including those related to increasing fuel loading and continuity across large landscapes and increased human-caused ignitions (Catry et al 2007); more scientists are focusing on global climate change and its effect on regional summer weather temperature and precipitation patterns as the "catalyst" that will turn fire potential into actual catastrophe. As Lourenço has noted: the stage has been set for the more frequent occurrence of a "catastrophic" fire year as hotter and dryer weather conditions mount *(*Lourenço, 2008).

Climate change researchers have been quite specific about weather conditions they see as particularly favorable to increased wildfire. Pereira has identified two weather based situations that would lead to this: first, long term dry periods followed by lack of precipitation in late spring and, second, a period of short term heat waves within longer periods of dry conditions (Pereira, 2004). Making matters worse, the longer-term outlook is for an increase in these kinds of summer weather events. Moreno has predicted an increasing risk cycle with high temperature variability, more frequent and intense heat waves, and lengthening dry spells and drought conditions (Moreno, J., 2009). Either of these weather factors (droughts and heat waves) can have a marked effect on increasing burned area. However, while the chance of both occurring simultaneously is mathematically small, it's increasingly probable. And, more importantly, recent research based on climate forecasting models suggests the likelihood of this escalating confluence of potentially catastrophic burning conditions is growing nearer.

For short periods of time, most notably during 2003 and 2005, burning conditions were so severe that fire protection system capability was clearly overwhelmed. Fire research has focused on 2003 and 2005 fire years first because of the magnitude of area burned but also because of the uncharacteristic weather factors differentiating each year, namely drought in 2005 and high rainfall and episodic heat waves in 2003 (Viegas, 2008). The weather factors stand in contrast to the most recent fire years where wet and milder summer conditions were such that it appears to have greatly minimized both the number of fire occurrences and the area burned (Viegas, 2008).

So the issue is why are milder summers an important factor in this equation of increasingly large burned areas? The answer may be in two parts. First, what doesn't burn in milder years becomes even more readily available to burn during future years with hot/dry summers. And second, milder summers also grow vegetation at an accelerated rate, due to less moisture stress, providing yet more fuel for future fires occurring in the next hot/dry summer. This concept that benign fire years are setting up more extreme fire years has not gone unnoticed. The Global Fire Monitoring Center – drawing on a number of sources of weather factors and fire in Portugal warns of a looming strategy–resource disconnect. *"Nevertheless, fire suppression measures have reached to reduce total annual area burned in relatively mild fire seasons but a latent potential for catastrophic fire events under adverse weather conditions reveals insufficient structural reforms rather than it reflects an increase of large fires driven by climate change, as could be seen in the case of Portugal"* (Goldhammer & Krause, 2008, p 2).

Ironically, the years of record low burned area (e.g. 2008) are as much an indicator of the effects of climate change as are the years of exceedingly high burned area. What's important to notice though is the increasing unpredictability in annual burned area pattern that's developed in less than a decade. From 2003 to 2008, annual burned area totals varied from under 15,000 hectares (2008) to over 450,000 hectares (2003); a 30 fold difference. That represents a huge range of potential annual fire activity. It begs the question what level of annual fire business (both in number of occurrences and burned area) and combat capability should fire protection services be funded and organized to successfully address? And, more importantly, can Portugal expect the near future to bring a wildfire season more severe than 2003?

Structural Fire Risk Factors: Fuels and Vegetation Condition

Climate change may be the most heralded global danger affecting fire, but it is not the only factor. Other significant changes have also been taking place over the last several decades that are having an ongoing detrimental effect on forest fire potential. The increase in burned area in Portugal has become the most noteworthy in all of Europe. A study by Nunes et al indicates that the 1070 km^2 mean annual area burned (over 1% of Portugal's land area) gives Portugal the highest ranking for fire incidence in Europe (Nunes et al., 2005).

While seasonal climate variations and the occurrence of severe weather events were important in the development of destructive forest fires, they were not the only relevant factors. Since the 1990's, the consensus of land management research attributes major blame to the neglected state of Portugal's woodlands and forests. In a 2005 analysis of wildfire burned areas in the 1990's, researchers noted the unique set of structural environmental conditions that have made Portugal so prone to wildland fires. The fine-scale geographic mosaic of less-flammable vegetation patterns that once existed due to well-tended private and community agricultural plots has now become overgrown with highly flammable weeds and shrubs. The reduction in herd sizes for grazing and the removal of fuel wood has also allowed fuels to accumulate (Nunes et al 2005). Marginally productive agricultural lands once converted to forest plantations are increasingly left unmanaged; too costly to maintain. These abandoned areas are overtaken by native shrubs and woody species making the country increasingly uniform in burning characteristics. Areas that once stopped fires, now fuel their intensity.

The growing structural fuels problem is further exacerbated by a general lack management of most forests as induced by:

- Poor economic attractiveness and undervaluation of non-woody values on products and services
- Inadequate Silviculture practices in eucalyptus and pine that result in overstocked stands
- Lack of economic stimulus for promoting biomass removal opportunities of understory vegetation through thinning and pruning activities

This is also true of the nearly million hectares burned between 2002 and 2005. They provided vast areas of low flammability vegetation that limited the size of some fires in the years that followed, particularly in 2007 and 2008 which were aided by mild meteorological conditions. Field visits to many of these burned areas confirm what many local fire commanders are saying, that they should no longer be considered as barriers to fire spread. In fact, the opposite is now true. In many burned areas forests have been replaced by more flammable shrubs and "dog hair" thickets of dense pine and eucalyptus reproduction. The fear is that the same areas could burn again, but in fewer days because fires will now spread even faster across this new landscape of continuous fuels.

While this changing face of landscape mosaics has been recognized for some time, only recently have the effects been associated with increasingly larger fires. One recent study by the Global Fire Monitoring Center has labeled the "devastating and almost uncontrollable" wildfires in 2003 as mega-fires (Goldhammer & Krause, 2007). Whatever the term, increased fuel continuity across large landscapes clearly exaggerates the potential for larger, more destructive forest fires. In many areas of Portugal, the ingredients already exist for a potentially disastrous large fire except one; the next severe fire weather event. The increasing inter-annual occurrence of wet years that contribute to increased fuels plus drought years that make fuels ever more flammable are setting the stage for the next generation of larger, more devastating fires. Ironically, it's these same conditions that exacerbate the forest insect and disease problems becoming prevalent in Portugal, including oak disease, pine nematode, gonipturos, and pulguinha do carvalho.

<u>Human Risk Factors: Fire Occurrence</u>

Yet another contributing factor that cannot be ignored is the unusually high occurrence of fire starts in Portugal from human-caused ignitions. Portugal, as compared with Mediterranean countries having similar fuel and weather conditions, has a disproportionately high number of human caused ignitions relative to population (Beighley, 2008) . Its Iberian Peninsula neighbor, Spain, is 5 times larger and has quadrouple the population, yet has fewer occurrences. While these numbers show a marked reduction in 2007 and 2008, mainland Portugal also experienced ignition reducing weather conditions for most of the those two summers. In fact, 2008 had one of the lowest burned area totals ever recorded.

While several new programs have been put in place over the last several years to reduce fire occurrence from human ignitions, it’s very difficult to determine their effectiveness as opposed to a reduction resulting from mild weather conditions. An attempt was made by researchers to compare the annual burned area and number of occurrences between the periods of 2001-2005 and 2006-2008, using a method to statistically neutralize the effects of weather. Their results suggest that recent system improvement had a positive effect. One very recent study has found that very positive progress has been acheived on three levels (ignition prevention, detection, initial response) between the first half and second halves of this decade (Fernandes, 2008). But everyone readily concedes that the real test will come when severe weather conditions are preceded by the next heat wave or ongoing spring/summer drought.

Another disturbing characteristic unique to Portugal is the high proportion of arson fires; fires intentionally set for malicious purposes. The rise in human-caused ignitions over the last several decades has several root causes that are often stimulated by changes in land-use policy, ongoing conflicts over land use, and social and economic tensions that are long term, even cultural in nature (Oliveira 2005). While unintentional or accidental fires can be significantly reduced through public education and awareness (“Sensibilization”) programs, these programs are not effective at reducing the occurrence of arson. Arson is a criminal act and the causes behind it are more psychological in nature. Other countries have responded to arson with serious penalties. In June of this year, an arsonist in California was sentenced to the death penalty for starting fires that killed 5 fire fighters attempting to defend a home.

The majority of ignitions in Portugal are directly associated with population centers and infrastructure. 98% of these ignitions occur within 2 km of urban areas. As researchers have noted, there is high correlation between fire ignition occurrence and population indicators (Catry et al 2007). The high number of ignitions also is realted to issues with contradictory public policies including grazing policies and subsidies, hunting permits, urban expansion and related proprietary conflicts. In contrast, more remote forested and uncultivated shrub and grassland areas that represent about 46% of the country, host less than 15% of fire ignitions. However, it’s often in these more remote locations that ignitions result in large fires. Detection is more challenging, first intervention response times are generally longer, and the terrain is more rugged and less accessible to ground fire combat forces and equipment.

Summary – A Wild Fire Risk Table for Portugal's Next Decade

The various risk factors reviewed in this assessment are collated into four fire scenarios for the next decade.

- **Scenario T_0** illustrates the normal fire year scenario where the burned area fire ceiling is normal – within 25% of the designated normal 100k hectares annual mean. This scenario has been achieved 4 out of 8 years in the current decade.

- **Scenario T-$_1$** represents an extremely low or benign fire year where burned area is more than 50% below the expected normal annual mean. This scenario has been achieved over the past two years (2007 & 2008).

- **Scenario T_1** displays the extreme fire year scenario where burned area minimum is 250,000 ha, as was the case in 2003 & 2005. This scenario has been achieved twice in the past eight years.

- **Scenario T_4** outlines a fire year that has not yet been experienced in modern times. This prospect, labeled the "climate change worst case scenario" would exceed the 500,000 ha ceiling which would translate into losses of over 10% of Portugal's forested, shrub, and rangelands areas. Also as the impacts of climate change mount, the probability for this scenario will likely to increase over time.

Figure 4 displays a general quantification of the shift in the expected annual occurrence of risk scenarios that is anticipated over the next decade. It projects the probabilities of annual occurrence for each scenario shifting over time from Recent Risk Factor to the Future Risk Factor (blue row). Under the asymmetric fire assumption, extreme years are more likely to outweigh normal years. In short, the new "normal" will be years where annual burned area will either be well below or well above the 100,000 ha target set for 2012.

For example, the recent risk factor for the "Extreme Low Year" (Scenario T-$_{1)}$ is rated at a 25% chance, as is risk factor for an Extreme High Year (Scenario T_1). The risk factor for a normal fire year (Scenario T_0) declines slightly to 0.45 Completing the picture, a risk factor for the Decadal Extreme fire year rises from zero (no record in recent history) to 5% in the coming decade (1 in 20). Over the next decade, the catastrophic risk of a potential fire season burning 500,000 ha or more in Portugal must be a serious consideration.

Why is this information valuable? In the last 3 years since major improvements in the system have been implemented, which risk scenarios have prevailed? 2006 fits the "Normal Fire Year" scenario and 2007 and 2008 fit the "Extreme Low Year" scenario. This begs the question, has sufficient planning and preparation been accomplished for responding to the Extreme High and Decadal Extreme Years that are likely to come? There's great value in thinking on these scales of magnitude given the prognosis of a changing climate.

Figure 4 – Fire Risk Schematic for Portugal's Next Decade

Climate Weather Scenario Weighted for Recent Experience (Since 2001) **Recent Risk Factor**	T_{-1} Extreme Low Year Asymmetric Low Severity Fire Year 2 in 8	T_0 Normal Fire Year* Moderate Severity (Near 100,00 ha 10-Year Mean) 4 in 8	T_1 Extreme High Year Asymmetric High Severity Fire Year 2 in 8	T_4 Decadal Extreme Year Worst Case Severity Fire Year No record
+/- 100k ha (01,02,04,06,07,08)	10%	90%	0%	0%
Over 250k ha (2003 or 2005)	0%	10%	80%	10%
Over 500,000 ha	0%	0%	10%	90%
Future Risk Factor	0.25	0.45	0.25	0.05

Conclusions Regarding Portugal's Future Fire Risk

- **The risk of an Extreme High Year (over 250,000 ha – i.e. 2003 & 2005) continues to increase**. The risk table estimates a relative increase from 0.2 for the last 10 years to between 0.25-0.3 for the coming decade. The higher probability (0.3) would be largely driven by further negative impacts by climate change and accumulating bio-mass. Climate change also is likely to extend the fire season beyond the traditional Bravo-Charlie-Delta period (15 May- 15 Oct).

- **The incidence of large fires (>100 ha) is increasing for summers with average to severe burning conditions;** both in terms of annual numbers and number of days with multiple large fires, and will continue to do so.

- **The frequency of concurrent multiple large fires and high numbers of fire occurrences is likely to increase in even normal fire years and certainly be a major issue for extreme fire years**. While a pattern has not yet formed, the probability that there will be high fire activity concurrently in multiple regions and that the number of extended fires (those lasting more than 72 hours) will increase is not trivial.

II Examining Fire Protection System Capability

For short periods of time during the summers of 2003 and 2005, Portugal's forest fire protection system was clearly overwhelmed by both high numbers of daily occurrences, with many days experiencing in excess of 500 new ignitions, and in area burned, with many days exceeding 10,000 new hectares burned. Certainly both these factors are somewhat co-dependent. An excessive number of daily occurrences can lead to delayed first intervention response times, allowing some fires to get bigger than what local forces can handle. Likewise, once large fires get established, they drain combat assets and reduce initial attack capability. This relationship becomes very important during more severe weather and burning conditions.

<u>Previous Assessments of System Functionality</u>

Over the past three decades, Portugal has been the subject of several reviews by forest fire experts from other countries, particularly the United States. Findings from these reviews have been relatively consistent, identifying 3 major areas needing improvement; (1) preventing unplanned human ignitions, (2) creating a structural fire defense system of fuel breaks and by reducing fuels in critical areas, and (3) improving fire combat capability to implement perimeter control strategies through training and reconfiguring some fire brigades as specialized hand crews. Once again, Portugal reacted to the devastation that occurred in 2003 with a strong intention to improve its forest fire defense capability. Several new reviews by national and international fire specialists yielded a long list of recommendations. Some recommendations were acted on immediately, and by 2004, improvements in emergency response coordination were made by collocating the Centro de Prevenção e Detecção (CPD) offices with the Centros Distritais de Operações de Socorro (CDOS) in many Districts.

Additional reviews took place during the 2004 fire season with many additional recommendations coming forward. The 2004 US-Portugal Technical fire Exchange report identified six categories of recommendations including:

Wildfire Incident Command and Control Structure—a determination to integrate all assets in the most effective way. Currently 3 separate and distinct fire combat organizations can operate independently on the same fire.

Wildfire Communication—a radio system that can immediately dedicate strategic and tactical frequencies for a limited and temporary theater of operations allowing all assets within that theater unrestricted communications with one another.

Wildfire Combat Assets—the necessary assets are in place with the notable exception of specialized hand crews. More assets of any kind can always be useful but the absence of a reliable source of hand crews is a significant handicap.

Perimeter Control Strategy and Tactics—much of the fire combat effort is targeted toward protecting homes while the perimeter of the fire goes unchecked. As a result, fires continue to grow threatening new areas. There is also a high percentage of rekindles because perimeters are not completely extinguished.

Balanced Wildland Fire Management Program—one that places equal value on prevention activities along with detection and combat. Most fires are human caused and many are preventable. Fuel reduction and Silviculture treatments are badly needed in some Districts. Fuels are quickly becoming more continuous and more flammable, covering vast landscapes.

Comprehensive Wildland Fire Management Training Program—capable of addressing the knowledge and skill needs from new recruit fire fighters, to fire brigade commanders, to municipal planners and community leaders.

In 2005 Portugal developed a technical strategy to implement all of these recommendations (ISA, 2005). In the year following, a "highly modified" version of the technical report was moved forward as the strategic national plan for improving the forest fire problem. The major difference between the two versions is that the technical plan emphasized a prevention strategy, while the "highly modified" version promoted a strategy that increased suppression capability. The *Plano Nacional de Defesa da Floresta Contra Incêndios (PNDFCI)* was approved and published, again with good intentions to move the recommendations to reality.

Institutional Reforms

Between 2003 and 2006, several attempts were made to reform state entities to address more effectively the growing forest fire probem. Authorities and responsibilities were juggled around in response to political posturing in what has been termed "successive restructuring" (DSVPF 2008). Some newly created entities, like the Forest Fires Prevention Agency (APIF) organized under the Minister of Agriculture, Rural Development and Fisheries (MADRP), had a very short life span before it was summarily deconstructed.

As it stands now, the National Forest Authority (AFN) is responsible for coordinating structural prevention (fuel breaks and fuels treatment), aspects of awareness, planning, organization of forest area, forest structure and infrastructure. The Republican National Guard (GNR) is responsible for coordinating operational prevention actions in the areas of surveillance, detection and law enforcement. And the Authority for National Civil Protection (ANPC) is responsible for initial attack and suppression, mop-up and post-fire coordination.

The parliamentary law creating these reforms also added additional regulations, policies and eventually forest defense against fire plans at the national, district and municipality level. Some of the new laws and policies overlapped with the existing, creating additional confusion. Landowners that thought they understood how the existing system worked were now finding this new path difficult to successfully navigate. While many reforms often gave the appearance of improving the fire defense system, they all suffered from the same deficiency, "rarely integrated with other public policies, the measures taken successively strengthened the ability of suppression by the mechanization of combat, rather than addressing the structural causes long identified" (ISA, 2005)

While attempts were made to acquire annual expenditures for all DFCI programs, insufficient records were made available. Still, some financial estimates indicate that upwards of 76% of the funds dedicated to DFCI activities are spent on combat (IdESEE 2009). This is like treating the symptom, not the disease. For example, it's like focusing most funding on treating disease symptoms after children become sick instead of immunizing them, thereby preventing the disease. While steps are being taken to remedy these deficiencies, they may not happen soon enough.

Currently, the tripartite division of DFCI program authority between ANPC, AFN and GNR allows the system to be only partially accountable. A single state management unit is needed with responsibility for evaluating and improving DFCI policy, for coordinating DFCI programs between ANPC, AFN and GNR, for total financial accountability, and for annual accomplishment reporting of PNDFCI objectives and targets. This independent management unit must also have access all financial records related to DFCI programs and activities. DFCI program effectiveness cannot be evaluated without having a complete picture of all expenditures, accomplishments and results achieved. This includes activities at all governmental levels, including municipalities. Currently the information necessary to accomplish any relevant program evaluation is either fragmented between responsible entities, inconsistently measured, or is inseparably combined with other information irrelevant for this purpose. An example is the case of the GNR—expenditures on DFCI are inseparable from the cost of all SEPNA services, which cover other areas of intervention in addition to those involving forest fires, making it impossible to identify costs specific to DFCI. A continuing program of integrated system improvements will be difficult, if not impossible, to achieve without a single state oversight entity.

Recent Improvements to System Capability

In 2008, a conference was hosted by the League for the Protection of Nature (LPN) to specifically identify system improvements made since the devastating 2003 fire season and to address improvements still needed. System improvements included:

- Organizational reform to create better program coordination and integration between government entities including the recent creation of the Aerial Means Agency (EMA)
- Increased specialization and professionalization in forest fire combat forces with the creation of Grupos de Intervenção de Proteccao e Socorro (GIPs) and Forças Especiais de Bombeiros Canarinhos (FEB), that includes 35 helicopter brigades of 5 to 9 firefighters each
- Increased peak season operational forces to over 9,500 personnel, over 2,200 vehicles and 56 aircraft (helicopters and fixed wing)
- Increased Sapadores Florestais crews to more than 260 for badly needed prevention, first intervention and mop-up work
- Improved expertise in fire use for both prescribed fire and suppression fire by creating the Grupos de Análise e Uso do Fogo (GAUF) with 21 technical fire behavior experts and also training 120 foresters in prescribed fire use techniques
- Improved local planning, with 234 municipalities having developed Forest Defense against Fire plans and staffing GTF offices with mostly Forest Engineers
- The initiation of a strategic fuel management program of fuel breaks and area treatments
- The creation of a national sensibilization program "Portugal sem fogos, depende de todos"

- Improved enforcement of fire laws with over 4,000 individual enforcement actions taken against violators in 2007
- The PNDFCI national plan includes goals that can be revised based on additional experience and conclusions drawn from experts like those resulting from the October 2008 LPN workshop

This represents only a partial list of GOP improvements acted on since the PNDFCI was implemented. What becomes increasingly clear is that the majority of the operational effort, as opposed to the planning effort, has been applied to increasing first intervention and combat capability. It's even more robust when Afocelca (Grupo PortucelSoporcel and Altri) assets are included (see Table 2). While fire response capability has clearly increased, is it enough to emphasize improvements to what only represents a third of the solution? It's this strategy-resource disconnect that's disturbing. The other two thirds of the strategic solution; preventing people from igniting alarming numbers of fires and reducing the fuels that continuing to grow unabated, have had far less effort.

<u>Limits to Forest Fire Combat Capability</u>

Every system has limits of capability. In wildland fire protection that limit is often determined by the number fires occurring on any single day and the severity of burning conditions that either complicate or contribute to a successful first intervention effort. A review of fire occurrence and weather data for the period from 2003-2007 shows episodes of multiple daily fire starts when the threshold for achieving first intervention success objectives was exceeded – reaching to levels of over 400 fires on some days (Viegas, 2008). Such levels would constitute a height that would exceed the fire suppression system capabilities of the current framework, even if the system was fully functional and operated flawlessly.

This isn't to say that the current fire detection, first intervention and initial attack system isn't capable. What any fire management system must recognize is that there are limits to reorganization and an expanded resource base, especially if the challenges are "geography and demographics" (Lourenço, 2008). The number of total daily occurrences becomes a significant factor in firefighting capability, particularly during severe weather and fuel conditions that propagate large fires. Specifically, a high number of fire occurrences is problematic in terms of detection and fuurther compounded when fires are widely dispersed (Catry, 2007).

Table 2 – Inventory of Portugal Fire Management Assets

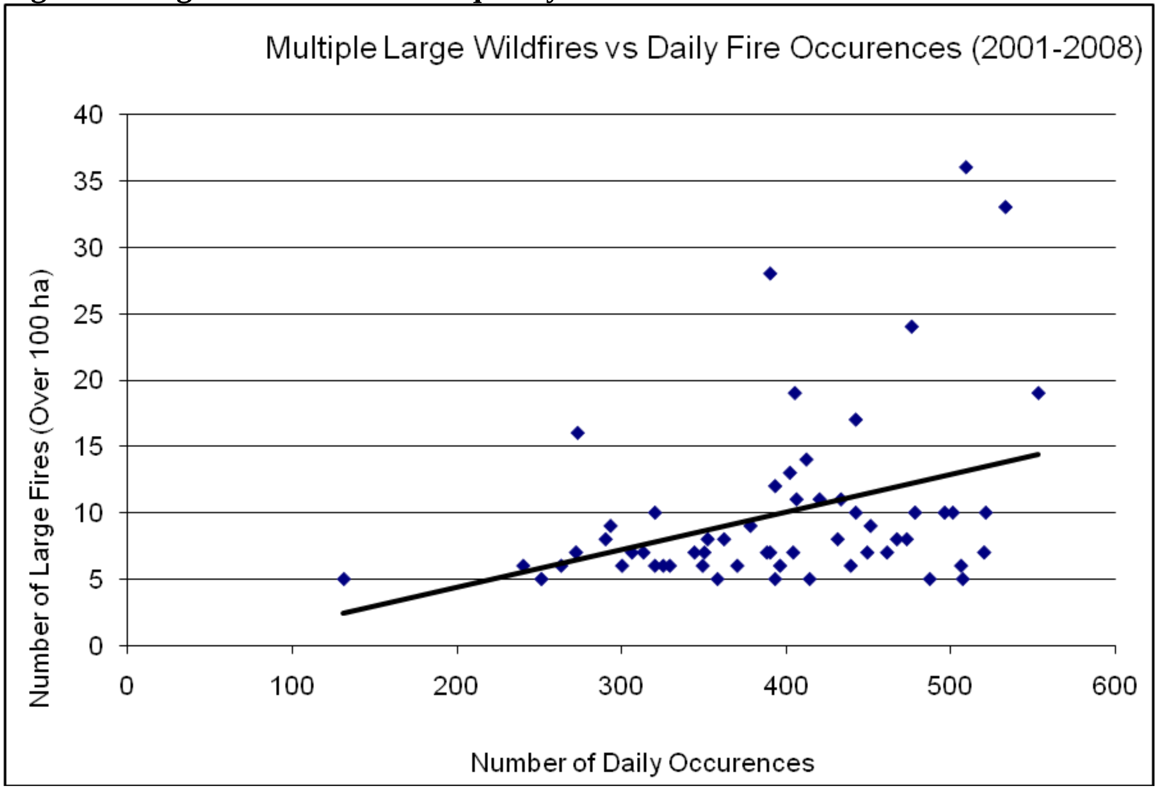
DFCI Operational Means, Phase Charlie, 1 July- 30 September 2009					
Entity	**Brigades/ Units**	**Fire Personnel**	**Vehicles**	**Heli copters**	**Air Tankers**
ANPC-National Assets				5	16
GNR-					
a) First Intervention -GIPS	92	638	92	20	
b) Environ. Protection (SEPNA)	306	819	404		
Bombeiros-					
a) Special Forces (FEB)	50	259	35	15	
b) Permanent Fire Brigades	120	600	120		
c) Volunteer Fire Brigades	983	4255	983		
d) Operational Fire Commanders	0	78	79		
Armed Forces Forest Fire Support (FA)	20	240	20		
AFN-					
a) First Intervention (ESF)	261	1305	261		
b) Forest Agents (CNAF)	75	300	75		
c) Fire Analysis and Use(GAUF)	8	24	8		
ICNB-Monitoring and Initial Attack	60	238	60		
Forest Fire Lookout Tower Staff	237	711	0		
Public Security Police (PSP)	28	216	28		
Afocelca (GPS/Altri)-					
a) Helitack Forest Fire Brigades*	4	20	0	4	
b) First Intervention Teams*	51	225	51		
c) Operations Supervisors	3	3	3		
d) Lookout Tower Staff	6	8	0		
Totals	***2304***	***9939***	***2219***	***44***	***16***

Sources: ANPC Directiva Operacional Nacional No 2/2009 and *Afocelca

Records clearly show that Portugal's fire response system can successfully detect, respond to, and extinguish more than 500 fires daily under milder burning conditions. However, when burning conditions become increasingly more severe, many more fires become large (>100 ha), suggesting that system first intervention/initial attack capability has been exceeded. Unfortunately, it's under these conditions, when large fires dominate the landscape, when most burned area occurs (JRC-IES, 2007)

The number of large fires that the fire protection system can accommodate is highly variable and is partially dependent on the total number of daily ignitions that occur during weather and fuel conditions conducive to large fire propagation. Per the discussion in part I, in the years from 2001-2008, Portugal has experienced 68 days with at least 5 large fires and 28 days with 10, or more, large fires. Since it's possible for large fires to occur even during mild fire danger days, we focused our attention on those days that experienced 5 or more large fires (days that are conducive to large fire propagation) and compared them against total occurrences on those days. The results are displayed in Figure 5. When burning conditions support large fires, a strong correlation exists between multiple large fire days (>5 large fires) and days with high numbers of total fire occurrences. We graphed this relationship and then established a trend line. While it would be useful to display fire weather or risk variables with this data, it would have to be done for each individual large fire (with up to 36 fires per day). This would shed even more light on system capability. We suspect the same weather and fuel conditions that support the development of large fires also promote fire starts from potential ignition sources.

Figure 5 Large Fires and Fire Frequency – Select Months



The combat system seems to function effectively on days with less than around 250 fires, even when weather conditions exist that promote large fire development. When the number of total daily fire occurrences approaches 400, the number of days with 10 or more large fires increases significantly. A case can be made that the system's breaking point seems to be on days when weather and fuel conditions support large fire propagation and daily fire occurrence exceeds about 400 fires. Why is this important too know? Ignition prevention becomes of paramount importance when weather conditions support large fire propagation, even more important than adding more combat forces. If, on these days, the number of occurrences could be kept to less than 250, far fewer large fires would result.

Reducing total ignitions is critical to improving the effectiveness of Portugal's fire detection and suppression efforts. This issue is especially pronounced in Portugal because as the number of ignitions increase, so does the occurrence density which stretches and spreads out initial fire response and extended suppression resources, lowering system effectiveness (Catry, 2007). Essentially, more fire occurrence over large areas spreads combat forces thin, making it more difficult to concentrate effort on any one problem fire. This overtaxing of the system leads to the need for prioritizing the first intervention/initial attack response. According to the 2009 Operations Plan emergency response priorities are established by the ANPC, who is responsible for all fire suppression. Priorities are established as follows and are appropriately placed on protecting human life and infrastructure:

1. Life
2. Buildings and other infrastructure
3. National parks and conservation areas
4. General forests and shrub lands

Unfortunately, this has significant implications for the potential effectiveness of fire suppression in commercial forests and unclassified wildlands. It appears what's best for the populace and communities may place Portugal's forests in higher jeopardy. When push comes to shove and there are more fires than what the system can effectively manage, forests will go without, or go with less than is needed to effectively stop perimeter spread. This situation most often occurs under severe burning conditions; those that cause fires to spread unchecked over vast areas. A recent report clearly conveys this concern: *"This is particularly true in Portugal where fire fighting is characterized by a very high priority being given to protection of houses and infrastructures, while minimal effort is allocated to fire perimeter containment over densely vegetated areas."* (Nunes et al, 2005 p. 665) How valuable are Portugal's forests and wildlands? Is there a better way to ensure they are not always the last to be protected when fire fighting resources are in short supply? Some have suggested that a professional forest fire organization is needed that only responds to forest fires.

Structural Prevention Requirements

Forests occupy about 68% of mainland Portuguese territory. Only 6% of Portuguese forest is owned by the Portuguese State, while most of the forest is privately or communally owned, mostly in small parcels. Most of this land can't be used for farming or other agricultural purposes due to soils and geography (Predosa, 2006). However, these forests contribute greatly to the wealth and well being of Portugal. Consider that:

- The forestry sector of the economy creates 260,000 direct jobs (3.3% of the active population) and 300,000 indirect jobs
- Forestry products assure the activity of over 7,000 companies
- Forest products represent 4% of Portugal's GDP and 11% of Portugal's exports
- Portugal's wealth extraction from forest amounts to 344 Euros/ha as compared to 90 Euros/ha for Spain and 292 Euros/ha for France. (Mendes, 2004)

Based on the economic and environmental importance of Portuguese forests, implementing widespread structural prevention measures that increase their resiliency to damage from fire should be a national obsession. While a completely fire-proofed forest isn't economically feasible, or practical, they can be managed in a condition that greatly improves their ability to survive fire. Creating a reliable and sustainable forest defense against fire is not just about reducing ignitions and improving combat capability. More forests need to be managed in a way that improves their ability to resist and survive fire. This generally involves three main characteristics of forests:

- Species selection and Silviculture methods
- Forest stand structural characteristics
- Landscape level patterns of differing age class and species diversity

Creating a defensible forest involves managing all three characteristics throughout the life of the forest. Unfortunately, in many cases, some forest owners and managers ignore, or intentionally omit, actively managing one or more of these characteristics, thereby increasing their forests risk to losses by fire.

Portugal seems to place a high value on fuel breaks as the method of choice for structural fire prevention. In fact, recent reports have claimed that over 250,000 ha of forests are now "protected" by fuel management activities (Mateus & Acadia, 2008). This largely consists of a network of primary and secondary fuel breaks designed to provide safe and strategic locations for taking effective combat action. However, under severe burning conditions, fuel breaks alone will not stop a fire nor will they reduce fire damage in the areas between them (Gould 2007). What fuel breaks offer is a strategic "anchor point" for instituting area-wide, landscape level fuel treatments like prescribed burning of understory litter in pine or for removing harvest debris from commercial eucalyptus plantations. Fire experts have long warned however that fuel breaks should not be seen as a single remedy and must be integrated into a broader based prescribed fire prevention effort aligned with an appropriate level of fire suppression capacity. (Agee, 1999) With that caveat in mind, area-wide treatments must also be of sufficient size to have an impact on the size of fire they're intended to influence. A 10 hectare treatment unit will have little effect on a 500 hectare fire that's spreading toward it. There must be sufficient numbers and dispersion of area-wide treatments among untreated areas so that fires run into them before getting excessively large.

Portugal's capability to plan and implement a diverse and wide-spread fuel treatment program has greatly improved in the last 5 years. Portugal now has 120 foresters trained in prescribed burning and has built a corps of technical fire use specialists, the Fire Use and Analysis Group (Grupos de Análise e Uso do Fogo—GAUF), that have a demonstrated record of success. Some private companies, like Grupo PortucelSoporcel are promoting landscape level fuel treatments and are also training teams of experienced prescribed fire specialists and becoming increasingly active on commercial forest lands. But with all this talent, the numbers of hectares burned using prescribed fire still fall far short of those burned in forest fires. And while thousands of hectares of commercial forest are harvested each year, few see any fuel reduction activities prior to plantation re-establishment, perpetuating an increasing ground fuel hazard.

One goal that Portugal should strive for is to conduct area-wide shrub land and forest management treatments on more area than is burned annually. This is an aggressive approach, but without it, Portugal's forest will continue to remain at high risk of damage by fire. Certainly there are many obstacles to overcome to implement such a robust fuel treatment and vegetation management program. Probably the greatest obstacle is the small size and diversity of ownership of most forest land, particularly in the central and northern areas. While some legal mechanisms have been established to facilitate organizing the many small property owners to take collective action, such as the Zones of Forest Intervention (Zonas de Intervenção Florestal—ZIF), few have progressed to the point of actually doing any work. The law enabling the creation of ZIFs was passed in 2005. And while 150 ZIFs are in the planning and formulation process, only 3 have been approved by AFN and no actual work on the ground has yet to be accomplished. This is primarily a result of the financing scheme which heavily funds planning and formation but then requires landowners to complete and pay for actual work before a request for partial cost reimbursement can be submitted. Even with these legal authorities in place, many things are still lacking, including:

- The desire of individual landowners to do work on their land that's in the best interest of the collective
- Economic attractiveness of forest products and services
- Effective leadership at community, municipal, and district levels
- Financial incentives (reduced taxes, etc.) that recognize the public benefit of private landowners taking action in the defense against forest fire

Until these issues are solved, the ZIFs will not result in any meaningful improvement.

Summary – Scorecard of Current Fire Management Capability

When viewing the fire problem in Portugal from a supply and demand perspective, the scorecard in Figure 6 shows a mixed result. System improvements are evident but may not be of sufficient significance to alter the burned area outcome when **above average to extreme** burning conditions exist. The result is that in 1 out of every 4 years on average, Portugal will be at risk of suffering significant forest fire losses.

Figure 6: Fire Management Scorecard

Supply Side	Demand Side
Combat capability has increased, especially in first intervention, initial attack and aerial means.	…but, the environmental risk of severe burning conditions that will occur in some years is increasing, and will challenge efforts to extinguish fires while small.
More aerial means exist to support large fire combat; aerial water dropping capability is greatly increased; dozers are available in most areas; command and control structures and support have been improved.	…but the system stills lacks specialized hand crew (hot shot) brigades which are critical to perimeter control strategies in remote forest areas. Too many rekindles exist and the extended attack system has not yet been tested by successive days of extreme burning conditions.
Efforts to reduce the numbers of preventable human ignitions are showing positive results.	…but the number of annual occurrences is still high compared to countries with similar conditions.
Structural fuel treatment planning and implementation skills have improved and the embryo of a viable structural defense program has been initiated in some areas.	…but fuels are being added much faster than they're being removed. Extensive burned areas from 2003 and 2005 are now ready to burn again with little management of forests outside of pulp company control.
Legal mechanisms have been put in place to organize small landowners to take effective, collective DFCI action.	…but most ZIFs are still in planning stages and not yet functioning as needed. A coordinated structural prevention effort over large landscapes by multiple small plot landowners continues to be rare.

III. Evaluation of Operational Effectiveness

While certain clues about operational capability can be gleaned from laws, policies, plans, operating guidelines, and analyzing data, nothing gives a clearer picture than observing the system respond to actual demand. Systems boasting impressive specifications often disappoint when worked under a load. In other cases, more basic designs are often far more effective than their simplicity might suggest. Anything can be made to look good in a sound bite or a planning document so it's essential to observe the actual performance of the forest fire defense system while under some level of stress.

From 28 July to 21 August, 2009, while in Portugal for the operational review, many key individuals were interviewed including numerous ANPC District Commanders and BV Commanders, a BV Association President, the Afocelca Executive Director and Regional Supervisors, Fire Managers and field supervisors for GPS and Altri, several GAUF Team Leaders, ANPC and Afocelca helicopter pilots, an Air Tractor pilot, and heli-brigade leaders for the GIPS, FEB and Afocelca. On-scene observations also were made of 6 fires that escaped initial attack in the Districts of Algarve, Porto, Castelo Branco, Vila Real, Viseu and Lisbon. The weather conditions these fires burned under can be best characterized as average August conditions.

Even though the 2009 fire season was below a normal fire year scenario, it did give the system a short test during normal summer conditions in late August and September that included 17 days of more than 250 fire occurrences. Embedded in that period were 12 days of 350 or more daily occurrences. The system responded well with no ascertainable failures. However, there are still important areas of improvement that are needed to provide an effective forest fire defense system during the more severe weather conditions that will eventually occur.

Fire Management System Staffing and Functionality

System Readiness Levels. The Alpha, Bravo, Charlie, Delta, and Echo operational preparedness levels are well understood and serve their purpose most of the time, but they're not easily responsive to atypical seasonal weather patterns. The 5 levels are established by preset dates based mostly on historical fire business. With seasonal weather patterns becoming more variable, historical fire business may not be as dependable an indicator as it once was. During periods of seasonally atypical weather patterns, this can result in a weak initial attack response during periods of elevated fire risk in the Alpha and Echo periods, which happened in March, 2009. Adding this flexibility could also promote an opportunity to free up some first intervention teams for conducting fuel treatments during lower risk periods in the summer.

Operational Coordination. The National Emergency Operations Command Center (Comando Nacional de Operações de Socorro or CNOS) holds weekly coordination meetings with key representatives from all DCFI cooperating agencies during the Bravo, Charlie, and Delta phases. This meeting is based on the premise that *"nobody is indispensible, complete cooperation is essential, and a single command function is necessary to provide the most effective response to fires"* (Gil Martins, personal comment). Similar meetings are also held at the District Emergency Operations Centers

(CDOS) that include representatives from public land agencies and major private companies and municipalities. These coordination meetings are an essential part of the DFCI system facilitating communication and more effective coordination between key response organizations.

Up to 3 command and coordination systems can be controlling different assets responding to a forest fire. The ANPC manages fire dispatch coordination for the majority of fire fighting assets; however, both the GIPS and Afocelca have independent systems running in parallel to the CNOS and CDOS centers. This is costly, inefficient and less effective than having all firefighting assets managed by a single coordination system.

Incident Command and Control Systems. The CDOS now have mobile command posts and many also have pre-organized fire command support teams to staff the command post. The more sophisticated command posts are equipped with the latest GIS mapping technology, GPS tracking of assets, satellite communication systems, and copy and FAX machines, large flat screen monitors to display maps and data, and portable power systems. What's missing was the preparation and distribution of a tactical plan for use by Sector Commanders and brigades. This is especially useful for commanders and fire brigades coming from other districts.

A single command authority, and only one, should exist on every fire. The fire command authority can be an individual, such as an ANPC District Commander, or it could be manifest as a "unified command" of several authorities that speak with one voice. The system in Portugal often times tolerates multiple command authorities. For example some fires had a fire commander from ANPC/BV and another one from Afocelca, commanding a different part of the fire on pulp company land. Often times the GIPS teams have an additional fire commander for their part of the operation. Running multiple, a parallel command system on the same fire is inefficient and can be unsafe if actions are not perfectly coordinated.

Communication Systems. Communication systems are undergoing a general upgrade with the ongoing implementation of the new SIRESP system with completion expected in 2010. This should greatly improve the functionality of the radio system. However, even with the new communication system operational, radio protocol issues still exist that could compromise safety and effectiveness on fires. For example, some GIPS heli-brigades communicate directly with their base rather than the commander on the fire. The information then gets relayed from the GIPS base to the CDOS and then to the commander on the fire. This introduces many opportunities for misinterpretation and human error and increases the time it takes to convey information.

Aerial Tactical Coordination. With the tremendous increase in numbers of tactical aerial assets comes the problem of airspace coordination over fires. It's not unusual to have multiple air tankers and helicopters of different types working the same fire. Mixing fixed and rotor wing assets can be tricky, if not dangerous, due to their different flight characteristics. And pilots have reported helicopters flying over the same fire in both clockwise and counter-clockwise rotations while communicating on different radio frequencies.

Initial Attack Suppression Response

Surveillance. Many improvements have been made including increased involvement of Sapadores, Afocelca brigades, Bombeiros brigades, GNR teams and Forest Association and pulp company employees in providing active surveillance during high risk periods. Some municipalities have also stepped-up their involvement. For example, in Mortagua, cultural associations contribute with planned patrols and are also equipped to provide first intervention action. Improved coverage by surveillance teams of GIPS and SEPNA, that are highly visible to the public, also provides a constant reminder about fire prevention. However, during periods of high fire risk, there are not always enough mobile surveillance teams to provide adequate coverage in more remote, interior forest areas with poor RNPV coverage.

Detection and First Alert. The effectiveness of the RNPV system is a point of weakness and has been termed "the Achilles' heel" of the DFCI system. Deficiencies include: (1) staffing towers with the chronically unemployed who have been given minimal training and often abandon their post, (2) inconsistent maintenance and reliability of video technology (mostly due to vandalism of cameras), and (3) inadequate geographic distribution of the RNPV towers. Slow detection times and the imprecise reporting of fire locations continue to compromise initial attack success.

First Intervention/Initial Attack. Reducing average initial attack response time is the most noticeable improvement in the system. With the addition of 35 GIPS/FEB professional helicopter brigades dedicated to initial attack, average response time has been reduced to 11 minutes (Gil Martins, personal contact). For 90 % of occurrences the response time is 20 minutes or less and all occurrences have firefighters on scene within 60 minutes of detection. Initial attack is the first priority for tactical aerial means and fire brigades are often prepositioned based on fire risk and known threats. The only deficiency in national heli-brigade coverage provided by the FEB and GIPS is in the south-western coastal area of the Alentejo. It would also be more efficient to have all helicopter brigades managed by the same government entity.

In some areas, more ground brigades are needed. In order to maintain initial attack readiness, the helicopter brigades are limited to 90 minutes on fires before they return to base to refuel. In more remote areas, fires have insufficient ground brigades on-scene to maintain control of the fire when the heli-brigades depart. The more this occurs, the higher the likelihood that more fires will go into the extended attack phase.

Investigation of Fire Causes. Effective fire cause determination and prosecution can only be accomplished if the fire spread indicators and evidence near the fire point of origin remains undisturbed until the fire investigators have finished gathering all relevant information. Too often, in their aggressiveness to put out the fire, fire fighters destroy valuable evidence and critical indicators. This leaves the fire investigator little to work from to make an accurate cause determination and to successfully gather evidence that may identify suspects and motives. The fires point of origin should be considered a crime scene until released by official investigators. Only then will useful information be gathered to improve fire prevention efforts.

Longer Term Suppression Response

Extended and Amplified Combat. While the most impressive improvements have been made in increasing initial attack capability, the ability of the system to organize an effective extended attack is also improved, but less so. Again, the most obvious improvement is the increase in heavy aerial means, including the 5 Kamov water bombing helicopters and 4 Air Tractor air tankers. Together with the 2 Canadair water scooping air tankers, these provide for a robust and time-extended water dropping capability that can be brought in when the initial attack copters leave, but often times there's no ground force present along the fire perimeter to work with the water being dropped. The further the fire perimeter is from roads, the more this becomes a problem.

Just as Portugal has strategic aerial means for extended attack operations, specialized extended attack ground forces are also needed, more so in forest areas where heavier fuels burn longer and take more work to extinguish. While many brigades, including BVs, GIPS, FEB, Afocelca, and Sapadores Florestais teams are trained in using hand tools and in fire line construction methods, few fire lines are constructed. If water is available, fire lines are avoided. This is a bad habit, especially in forests. Also, ground brigades often need to remain on the fire beyond the initial attack period. These are the same brigades that need to be available for new fires. This double-duty weakens the initial attack system and is one reason why the percentage of rekindle fires is high; because brigades are often pulled away from a fire prematurely, to respond to new initial attack demands.

While several areas have dozers available, the means to immediately get them transported to the fire are limited. When they arrive at the fire location, it's unclear how or where they are to be used. And, because so few dozers have been used on large fires, dozer operators have little experience in working them in fire situations and fire commanders have few sources of expertise to rely on for tactical advice.

Mop-up and Rekindles. Between 2% and 6% of annual fire occurrences can be blamed on firefighters that do an incomplete job of completely extinguishing fires. In 2008, 321 occurrences were the result of fires rekindling after firefighters thought they had put them out. While that number is down from the 537 rekindles experienced in 2007, it's still more than double the < 1% goal in the PNDFCI. Many of these rekindles occur in inaccessible areas of fires that are not properly mopped up. This is a job best done with hand tools working with water, not just using water alone! This is another justification of the need for specialized extended attack hand crew brigades. Many of these fires are completely preventable!

Summary of Review Observations & Findings

- **Fire Management System Staffing and Functionality**

Great improvements have been made in operational readiness, national and district level interagency coordination, and fire incident command and control. However, the continued toleration of more than one commander for a fire and the lack of tactical airspace coordination when using multiple types of aircraft on fires, both increase the potential for system failure. The jury is still out on the effectiveness of the new SIRESP communications system until fully deployed in 2010.

- **Initial Attack Suppression Response**

Surveillance, first intervention and initial attack are aggressive and highly effective when fires are quickly detected and accurate locations are reported. However, huge deficiencies still exist in the detection system, particularly in management of the RVPV towers. Slow detection and reporting inaccurate locations of fires significantly reduces initial attack success. Fire cause and criminal evidence is often disturbed by the first arriving fire brigades resulting in a low probability of accurate cause determination and the apprehension of suspects.

- **Longer term Suppression Response**

The system has greatly increased aerial capability for continued assault on extended attack fires. However, this can far exceed the capability of firefighters on the ground to make effective use of the water drops. The construction of fire lines, other than by using existing roads, is still relatively rare. This deficiency contributes to an unacceptably high percentage of rekindles.

IV Concluding Recommendations

Since each section of the report has a summary assessment of core findings, it is not our intent to repeat them in this closing section. Rather this last chapter is organized into 6 core recommendation areas – ranging from strategic to tactical to future investments.

I. Strategic Fire System Planning and Risk Management

Portugal's fire management system needs to ensure that it has adequate strategic planning and risk management processes in place to be able to handle the increasing probability of extreme and ultra-extreme fire years. The forest fire environment, driven by climate change, land condition, and demographic factors will see an increase in risk of large fire years, larger fires, concurrent fire activity, and extended fire seasons. Building an even bigger fire suppression force is not the solution--rather Portugal must invest in better fire prevention (to include prescribed fire and other forms of fuels reduction) and develop and enhance the current fire combat system to master the demands of the next extreme fire year.

II. Enhanced Fire Prevention - Fire Preparedness and Support

Forest fire preparedness levels should be more closely tied to actual fire risk. Fire combat readiness levels imposed by rigid, pre-set dates, such as those directed by the annual Directiva Operacional National Plan (i.e. Phase Charlie), often fail to match current fire risk with appropriate readiness. Historical fire risk patterns are changing and fire readiness levels should be more closely linked with actual fire risk, as measured by the FWI or other indicator, regardless of the season.

Prioritize financing for prevention actions to ZIFs in high or very high fire risk areas. Efforts to organize small landowners to take effective collective action are stalled in the planning and formation phase. Few, if any, ZIFs are actually resulting in fuel treatments that reduce fire risk. Provide additional expertise, support and incentives for landowners to complete fuel treatments. The ZIF concept is useless if it doesn't result in significant structural forest fire prevention results. The increase in asymmetric fire seasons will provide more opportunity in lower risk years to complete fuel treatments that will provide increased protection during high risk fire years.

III. Stronger Tactical Fire Suppression - Coordination and Accountability

Independent GIPS and Afocelca forest fire command and coordination systems should be fully integrated with the ANPC command and coordination system at the CNOS and CDOS levels. These operations coordination centers should include GIPS and Afocelca staff with decision-making authority but all communications and decision support should be funnelled through only one dispatch center.

BV Commanders need to hold their brigade leaders accountable for protecting the point of origin until SEPNA and PJ Officers have arrived to take charge of protecting what constitutes a potential crime scene. BV brigades do not respect the importance of fire cause determination in solving the forest fire problem in Portugal. In their exuberance to put out fires, they destroy critical fire cause indicators and evidence that make successful cause determination and criminal prosecution almost impossible.

ANPC should be responsible for operational management of all aerial means used for forest fire combat. As part this responsibility they should provide an aerial means for airspace coordination immediately over fires involving more than 2 aircraft. This is especially important when using a combination of helicopters and air tankers. All heli-brigades should operate under a single command authority; GIPS or FEB. ANPC should place an additional heli-brigade near Odemira, completing national coverage for all major forest areas**.**

More ground brigades are needed, specialized in perimeter control, and positioned to arrive on fires before the 90 minute heli-brigade limit is reached. These specialized brigades should be equipped for 24 hour, self-sustained operational capability. Equip and train these extended attack brigades to support GAUF suppression fire and prescribed fire actions.

IV. Training & Development Investments

Reorganize the Sapadores Florestais program under a centralized management structure that can provide a consistent system of operational accountability and readiness. The program is well-intentioned but suffers from lack of management consistency and standardization. Annual employee turnover is high in many areas and training for new team members is often not provided by the hosting unit (usually a municipality or forest owners association). On many teams only one person has received the official training.

SEPNA needs to overhaul their management of the RNPV towers. Currently the SEPNA is attempting to staff RNPV structures with the chronically unemployed and making little investment in training. These individuals often abandon the towers at critical times leaving gaping holes in the detection system. Many fires starting after dark go undetected for hours because critical RNPV towers are not staffed at night.

Establish an effective Back-to-Work Program. If an objective of the GOP is to hire the chronically unemployed, then organize a program under the AFN for doing structural fire prevention, similar to the Sapadores Florestais program. This would be a more productive use of the unemployed than the current practice of hiring them to staff RNPV towers.

V. Investments in Evaluation and Research

Portugal needs a central management and accounting entity that has access to financial records and accomplishment reports for all activities associated with the DFCI. Portugal has no central system of accountability for expenses and accomplishments related to the PNDFCI targets and objectives. This makes it almost impossible to assess the value of different program components (fire combat/ignition prevention/structural fuel prevention) versus their cost.

Establish a fire science community of practitioners and scientists to identify knowledge and technology needs specific to improving the forest fire problem in Portugal. A disconnect exists between the forest fire research community and practitioners. While new science is being produced, it may not be immediately useful to the practitioners who have not expressed their specific needs.

Concluding Remarks

The GOP has made large investments in increased combat capability, particularly in improved first intervention, initial attack and extended attack aerial means. While opportunities for continuing improvement in combat still exist, far more effort is needed, and a larger payoff can be expected, from future investments in improved detection systems and coordinated structural prevention efforts. Even in California, with the worlds most sophisticated and expensive forest fire combat system, modern technology often becomes overwhelmed by extreme fire. This doesn't mean that the combat system has failed; it merely demonstrates that there are physical limitations to any combat system's capability. This is why structure prevention is so critically important. Nations and states can't control weather, or the occurrence of droughts or heat waves. However, they can act to control how much fuel is available to burn and its distribution across the landscape. It's the only means for reducing fire intensity to a level where combat systems can be effective during the more extreme weather conditions that are sure to come.

The Portuguese society must also learn to appreciate the importance of their forest resources. Only then will they think twice about changing their behavior regarding carelessness and misuse of fire. The Portuguese are the forest fire problem; but they're also the forest fire solution.

Appendix A: Risk under Asymmetric Fire Conditions

Portugal is not the only country in the world which is experiencing dramatic new levels of fire frequency and severity. In the United States, the 2009 Quadrennial Fire Review described the American fire experience in this decade as displaying such high levels of annual variability or the lack of predictable patterns to warrant being considered under a new construct termed “asymmetric fire” for evaluating the shape of the future wildfire management environment (NWCG-EB, Hyde, 2009). Asymmetric is used to identify a data pattern where the skew within the data is more significant than central tendency; in short, where there's no obvious norm and large variation, both within regions and among them, over the time period.

This especially extends to regional differences compared to national norms. Basically, the 2009 QFR acknowledged that the use of averages of numbers of fires and total of acres burned in the US over 2000-2008 is particularly unreliable & uninformative, except perhaps to convey the very rough overall magnitudes of difference between regions. As an illustration, Figures A1-A4 plot fire frequencies and area burned in Portugal compared to Northern and Southern California from 2001 to 2008. These figures highlighting fire frequency and area burned display the highs and lows expected of the last decade of fire in both Portugal and California in which the extremes prevail. While a good visual demonstration of fire over the last decade, they are of little value in helping predict where fire is headed next.

Figure A-1 Risk Spectrum of Portugal Fires

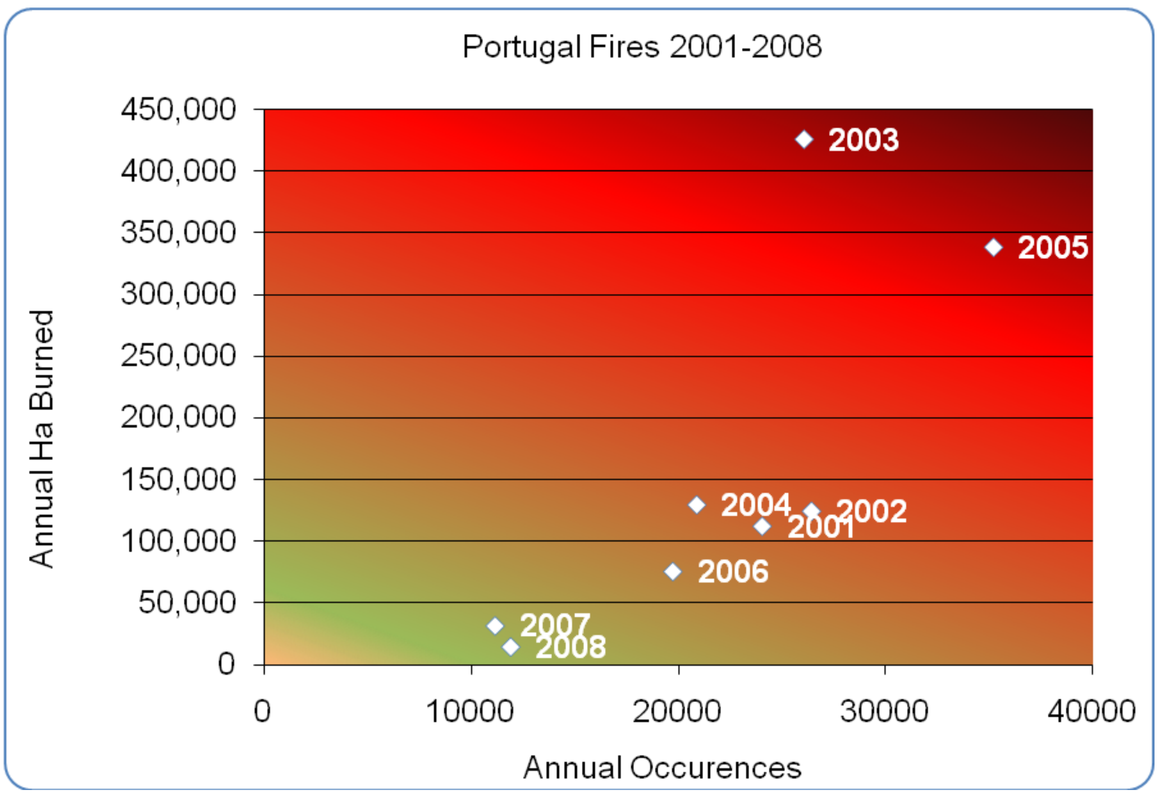


Figure A-2 – Fire Occurrence & Burned Area in Portugal

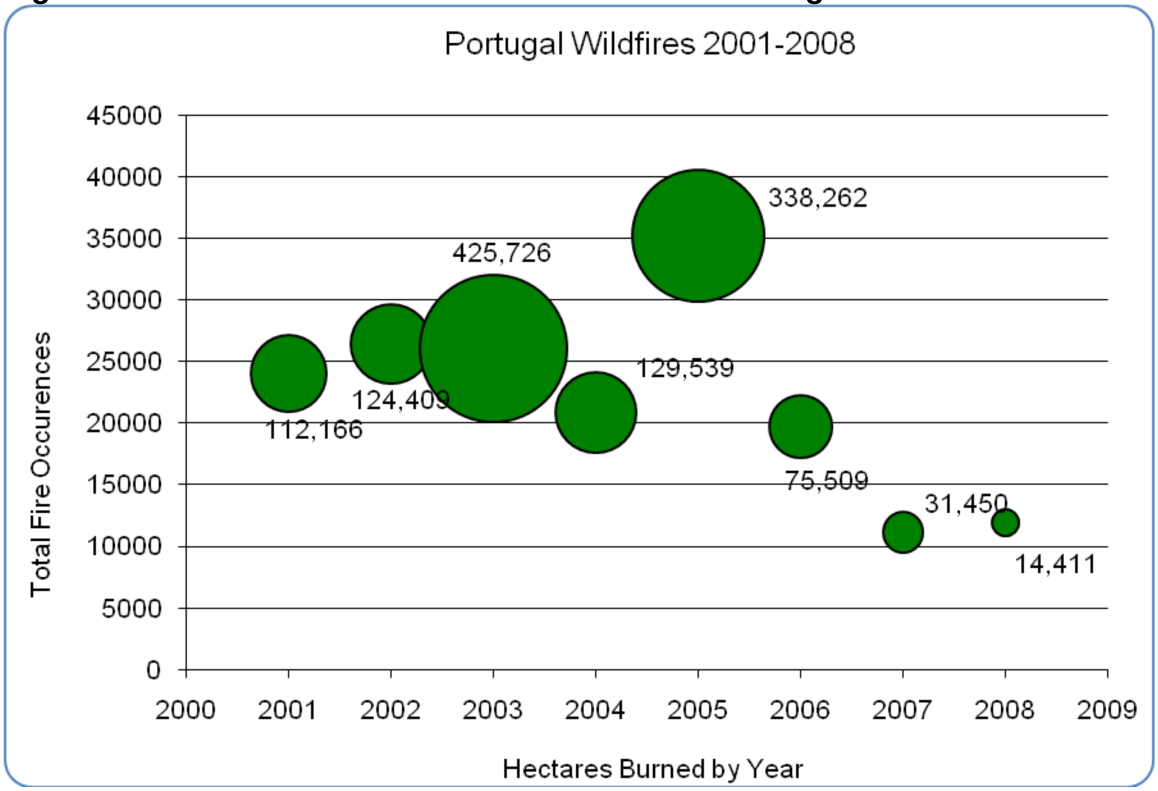
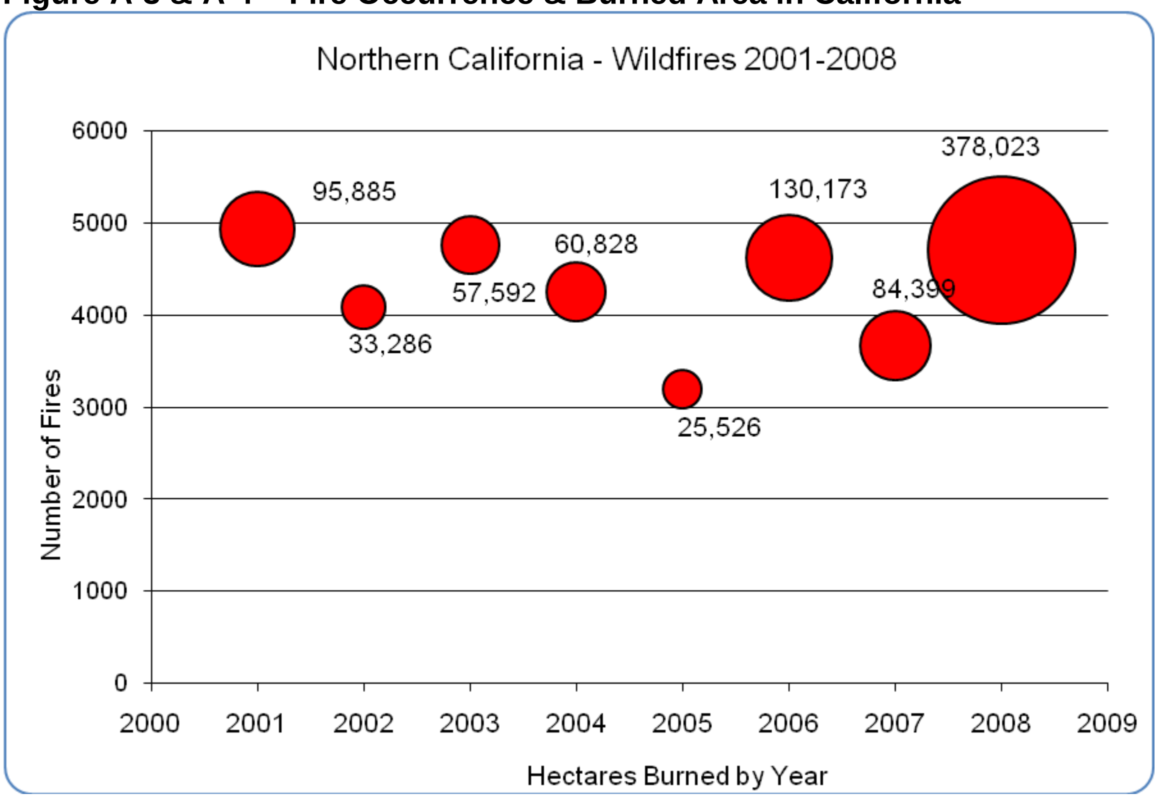
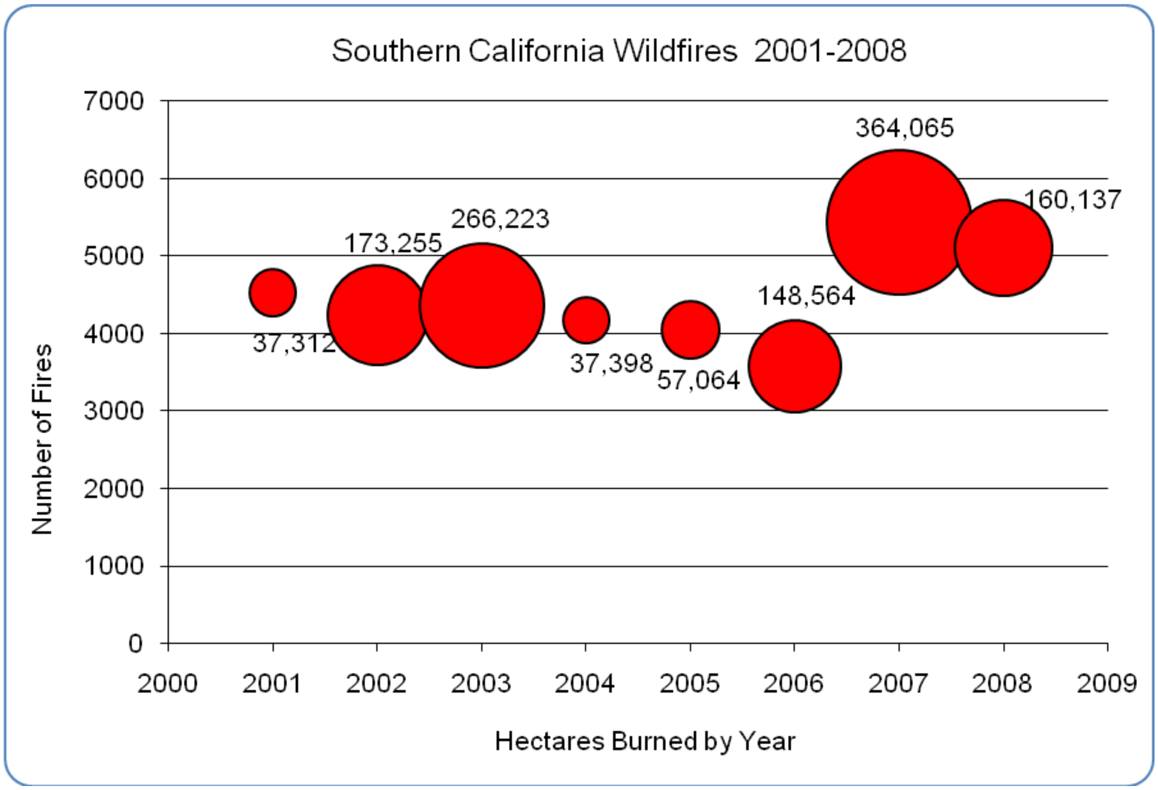


Figure A-3 & A-4 – Fire Occurrence & Burned Area in California



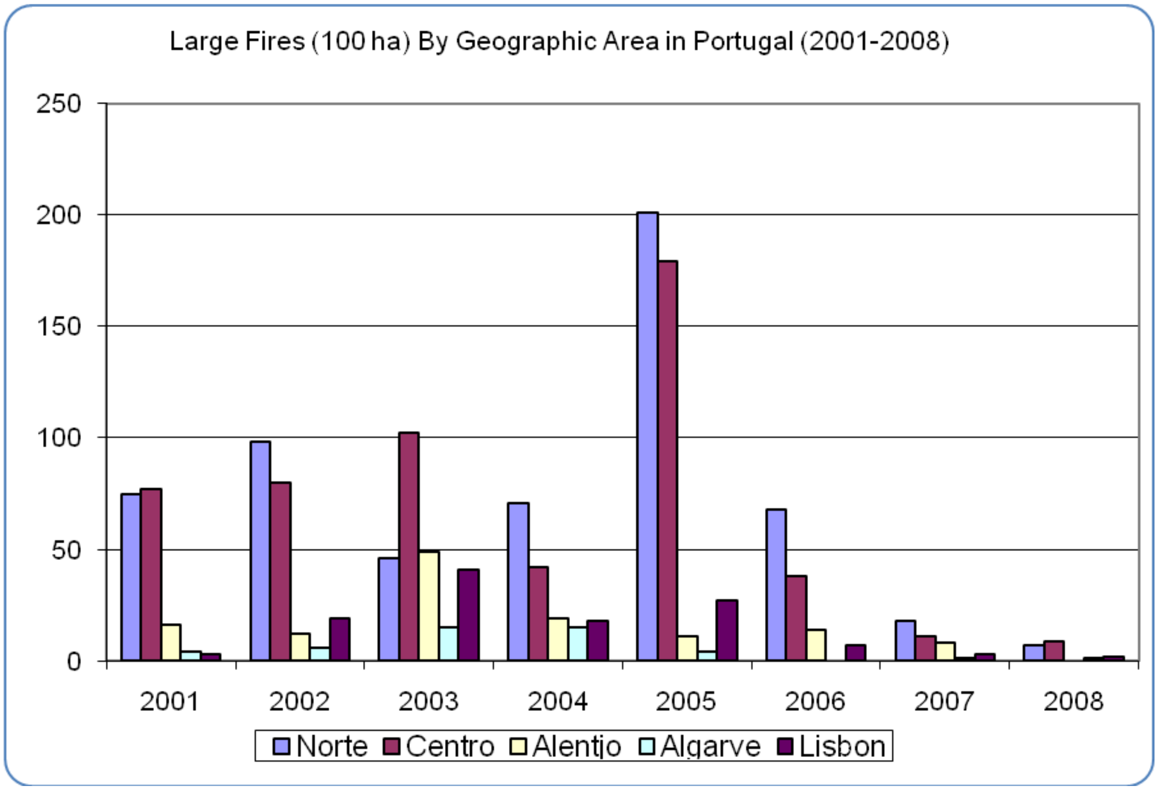


A significant dimension of asymmetric fire is the high annual variability of large fires. This trend has also emerged in the United States as the recent QFR noted – large fires (over 50,000 acres) have increased significantly in number since 2000. In Portugal the trend is more pronounced as Figure A-5 demonstrates. Numbers of large fires (in this case those listed as 100 ha) were actually most pronounced in 2005 even though total burned area was greater in 2003. The risk factor being considered is whether national forces will have to confront large fires on multiple fronts, in different geographic areas**.** In half of the eight years since 2001, there have been at least two regions with 50 large fires in the same year.

Even in lower fire years, like 2004 and 2006, at least one geographic area had more than 50 large fires. Only in the last 2 years, when total numbers of fires were well below the decadal mean, were large fires not a factor. Summarizing the risk variables, the last 8 years have show a 0.5 probability that there would be at least 2 regions with over 50 large fires to contend with.

Compounding the large fire risk factor in multiple regions is the factor of multiple large fire occurrences in same time period. The greater the number of fires that occur during weather suitable for propagating large fires, the higher the probability of having more large fires burning in the same period. Figure A-6 shows a two sided scaled graph depicting select days in July & August (60 day period) from 2002 to 2006 where there were both over 100 fires and the corresponding number of large fires over 100 ha. The risk probabilities for specific situations developing during July and August are shown in figure A-5.

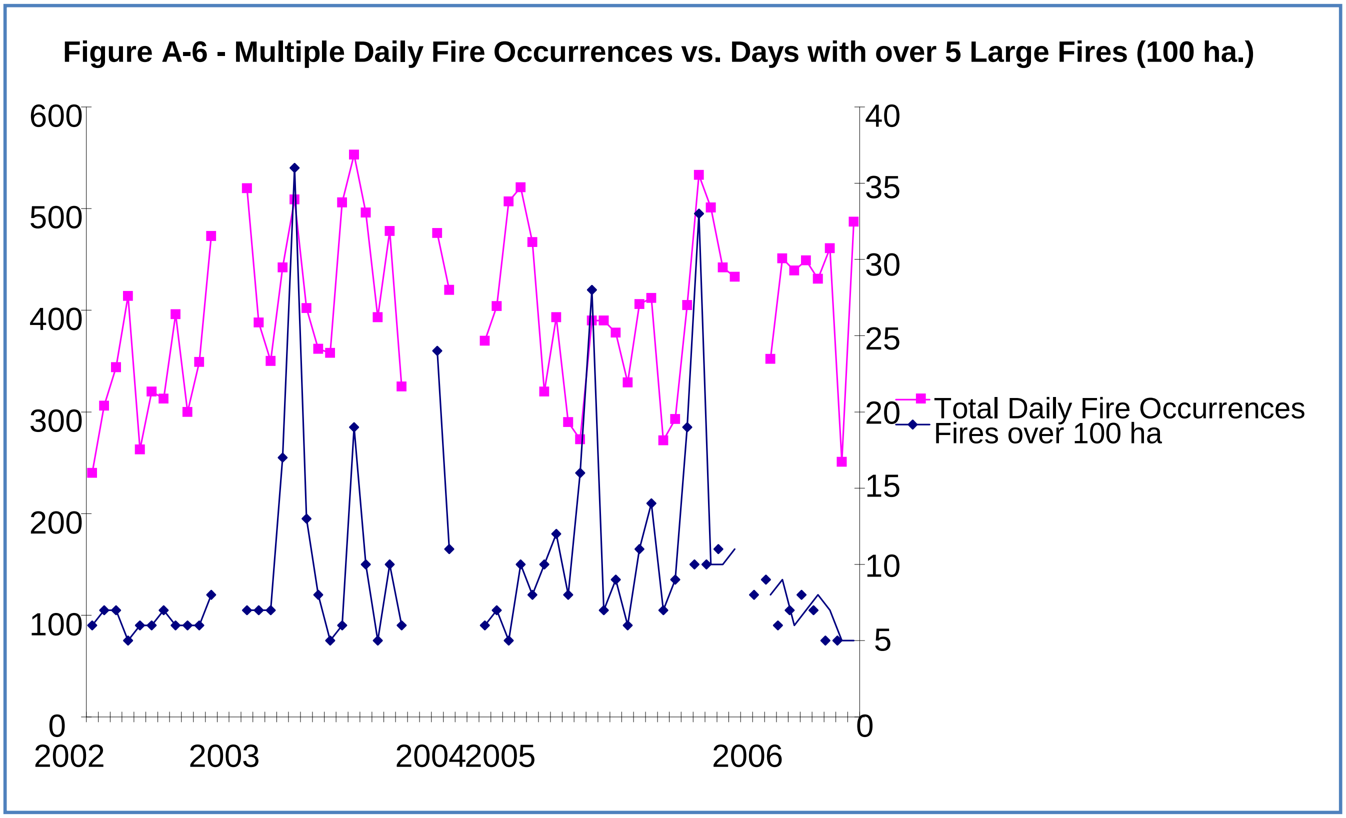
Figure A-5 – Regional Distribution of Large Fires (Over 100 ha) in Portugal



Source: Direccao General Das Florestas Legende DGRF Registos 2001-2006 and **2007**-2008 **(**Aggregate data Base of All fires in Portugal – downloaded from DGRF) Sorted by Region.

The period of July and August, 2002-2006 (240 days)	Days	Risk
Number of Days with Over 200 fire occurrences	120	.5
Number of Days with 200-300 fires & 5-10 large fires (100 ha)	8	.067
Number of Days with 300-500 fires &10-20 large fires (100 ha)	13	.108
Number of Days with Over 500 fires & 20 large fires (100 ha)	3	.025

Source: Data taken from Direccao General Das Florestas Legende DGRF Registos 2001-2006 and 2007-2008.



In closing this brief look at wild fire dynamics in Portugal, it might be important to note what this section of the report is not saying. There is an evolving debate in fire research about the impact of large fires and the devastation they cause. The question was perhaps first asked in the late 1980's whether large fires account for most of areas of wildlands burned each year -- essentially "do 1% of the fires do 99% of the damage" (Strauss et al. 1989, p. 319). This has been recast recently in terms of suppression effort by assessments in the U.S. indicating that just over 1% large fires account for almost 95% of fire costs (Holmes et al 2008). Interesting as this may be, this is not the issue in Portugal. Even in 2003, large fires (over 500 ha) were approximately 2% of total forest fires accounting for just over 80% of area burned – See Table 1 in main report).

The point of asymmetric fire is that fire suppression capability is likely to confront non-patterns that will be hard to predict and even more difficult to scale up or down to deal with extreme fire years one season and benign fire seasons the next. What this would point to in terms of risk management would be that the most optimal strategy will be one that matches an agile and well-coordinated suppression response capability with a more effective effort in fire prevention and fuels management. In Portugal, with its interface demographics and ownership patterns, any strategic solution must include preventing people from igniting alarming numbers of fires and reducing the fuels that continuing to grow unabated.

Table A1 Annual Burned Area Totals Portugal 1980-2008

Year	Burned Area	Occurrences		Year	Burned Area	Occurrences
1980	44,251	2349		2000	159,604	33526
1981	89,798	6730		2001	112,166	24038
1982	39,556	3626		2002	124,409	26416
1983	47,811	4539		2003	425,726	26059
1984	52,710	7356		2004	129,539	20884
1985	146,254	8441		2005	338,262	35195
1986	89,522	5036		2006	75,509	19731
1987	76,269	7705		2007	31,450	11161
1988	22,434	6131		2008	14,411	11914
1989	126,237	21896				
1990	137,252	10745		**1980-89 Mean**	**73,484**	**7,380**
1991	182,468	14327		**1990-99 Mean**	**102,201**	**22,023**
1992	57,012	14954		**2000-08 Mean**	**156,786**	**23,214**
1993	49,963	16101				
1994	77,323	19983				
1995	169,612	34116				
1996	88,867	28626				
1997	30,535	23497				
1998	158,368	32790				
1999	70,613	25095				

Source: AFN

Appendix B List of Interviews

Paulo Mateus, AFN, Director Nacional Incêndios, 29 May 2009 (Coimbra)
João Pinho, AFN, Director Nacional Planeamento, 19 May 2009 (Lisboa)
Rui Almeida, AFN, Director Unidade DFCI, 29 May 2009 (Coimbra)
Manuel Rainha, AFN, Cf. Area Florestal, Porto, 22 May 2009 (Valongo)
António Salgueiro, AFN, GAUF, 21 May 2009 (Lousa)
Pedro Palheiro, AFN, GAUF, 21 May 2009 (Lousa)
Jose Rosendo, AFN, Algarve District, 27 May 2009 (Odemira)
André Rebelo, AFN Gauf, and Mihno Forest Association, 23 May 2009 (Porto)
Silvino de Sousa, AFN, Porto District, 22 May 2009 (Valongo)
Paulo Albino, AFN, Guarda District, 26 May 2009 (Manteigas)

Gil Martins, ANPC, Comandante Nacional Operacional Socorro, 28 May 2009 (Lisboa)
Joaquim Chambel, ANPC, Comandante Operacional, Santarem District, 26 May 2009 (Tomar)
Rui Natário, ANPC, 2nd Comandante Operacional, Santatém District 19 August, 2009 (Constância)
Rui Esteves, ANPC, Comandante Operacional, Castelo Branco District, 11 August, 2009 (Castelo Branco)
Vaz Pinto, ANPC, Comandante Operacional, Faro District, 8August 2009 (Tavira)

Gabriela Fernandes, President, Bombeiros Voluntarios de Almocageme, 31 July 2009 (Almocageme)
Bruno Tomas, Comandante, Bombeiros Voluntarios de Almocageme, 28 July 2009 (Almocageme)
Rodolfo Batista, Comandante, Bombeiros Voluntarios de Merceana, 7 August 2009 (Merceana)
"Bismark", Commandante Bombeiros Voluntarios de Albergaria -a-Vehla, 25 May 2009 (Albergaria)
Vitor Matos, 2nd Comandante, Bombeiros Voluntarios de Almocageme, 28 July 2009 (Almocageme)

Lieutenant Colonel Antonio Paixão, GNR, Comandante GIPS, 28 May 2009 (Lisboa)
Major Amado, GNR, Comandante SEPNA, 19May 2009 (Lisboa)
Major Fernando Jorge Miranda, GNR, Castelo Branco, 12 August, 2009 (Castelo Branco)

José Lopez, Polícia Judiciaria, Castelo Branco, 12 August, 2009 (Castelo Branco)

Luís Grilo, ICNB, Coimbra, 26 May 2009 (Seia)
Rafael e António, ICNB, Serra d' Estrela, 26 May 2009 (Seia)

Teresa Abrantes, IM, Head of Department, 28 May 2009 (Lisbon)
Pedro Viterbo, IM, Scientific Coordinator, Gestor do Projecto Land SAF, 28 May 2009 (Lisboa)

Viriato Soromenho-Marques, Calouste Gulbenkian Foundation, Scientific Coordinator, 28 May 2009 (Lisbon)

Miguel Galante, Forest Engineer, Governor's Office, Lisboa District, 7 August 2009 (Sintra)
Afonso Sequeira Abrantes, Mayor, Mortagua Municipality, 25 May 2009 (Mortágua)
Pedro Carrilho, Tapada Nacional de Mafra, 7 August, 2009 (Mafra)

Rosario Alves, Florestis, 22 May 2009 (Penafiel)
Antonio Loureio, Unimadeiras Forest Owners Association, 25 May 2009 (Albergaria)
Luís Sarabando, Baixo Vouga Forest Owners Association, 25 May 2009 (Albergaria)
Mariana Ribeiro Teles, Forest Associations of Coruche, 20 May 2009 (Coruche)
Patrícia Matos, ACHAR (Almeirim/Alpiarca/Chamusca), 17 August, 2009 (Chamusca)
Amália Neto, Vale do Sousa Forest Owners Association, 22 May 2009 (Penafiel)
Paulo Bessa, Penafiel Municipality GTF Office, 22 May 2009 (Penafiel)
Nuno Calado, Forest Associations of Coruche, 20 May 2009 (Coruche)

Orlando Ormazabal, Director, Afocelca, 25 May and 13 August 2009 (Figueira da Foz)
Pedro Pedrosa, Helibravo Pilot, Afocelca, 9 August, 2009 (Odemira)
Francisco Aruta, South Supervisor, Afocelca, 9 August, 2009 (Odemira)
Oliveira Martins, Central Supervisor, Afocelca, 11 August, 2009 (Castelo Branco)

Tiago Oliveira, Forest Fire Manager, Grupo PortucelSoporcel, 18 August, 2009 (Caniceira)
José Luis Carvalho, Commercial Director, Enerforest, Grupo PortucelSoporcel, 6 August 2009 (Lisboa)
Francisco Inacio, Local Supervisor, Grupo PortucelSoporcel, 18 August, 2009 (Caniceira)
José Guerreiro, Local Supervisor, Grupo PortucelSoporcel,18 August, 2009 (Caniceira)
Melo Bandeira, Local Supervisor, Grupo PortucelSoporcel, 18 August, 2009 (Caniceira)
Ricardo Mendes, Local Supervisor, Grupo PortucelSoporcel, 18 August, 2009 (Caniceira)
António Colaço, Local Supervisor, Grupo PortucelSoporcel, 7 August 2009 (Torres Vedras)

Pais de Oliveira, Forest Fire Manager, Altri Group, 14 August, 2009 (Constancia)

Paulo Fernandes, University of Trás-os-Montes and Alto Douro, 22 May 2009 (Vila Real)
José Miguel Cardoso Pereira, Instituto Superior de Agronomia, 29 May 2009 (Lisboa)
Francisco Castro Rego, Instituto Superior de Agronomia 20 May 2009 (Lisboa)
Xavier Viegas, Universidade de Coimbra, 20 May 2009 (Lisboa)
Carlos Câmara, Universidade de Coimbra, 20 May 2009 (Lisboa)
Ricardo Trigo, Universidade de Coimbra, 20 May 2009 (Lisboa)
Guillermo Julio Alvear, Professor Titular, Universidad De Chili, 18 August, 2009 (Caniceira)

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Appendix D Report Authors

Mark Beighley

Mark Beighley is currently an independent consultant advising public and private sector clients in the areas of wildland fire management, strategic planning, and budget and cost analysis. He founded Beighley Consulting LLC in 2008.

He has over 34 years in professional fire management experience in the U.S. federal service starting from basic fire fighter and a fire engine captain before retiring in 2008 as a senior executive as Director of the Office of Wildland Fire Coordination, the highest ranking fire career executive position in the US Department of the Interior in Washington DC. As National Program Director for Wildland Fire Coordination with Interior, he was responsible for coordinating the Department's wildland fire programs. He coordinated national budget and policy development between four DOI bureaus involved with wildland fire and the US Forest Service, prepared testimony and briefed the Secretary of the Interior, the Office of Management and Budget, and Congressional Appropriations Committee members and staff on wildland fire issues, budget, and policy.

Prior to his promotion to the National Program Director for Wildland Fire in Interior, he held a number of senior management positions within the U.S. Forest Service. He was Assistant Director for Budget and Planning, Fire and Aviation Management where his major roles included formulation and execution of the Forest Service wildland fire budget; coordinating wildland fire international program assistance; identifying and coordinating wildland fire program research needs; coordinating state and volunteer fire assistance programs; and overseeing planning for wildland fire information technology.

Before becoming a part of National Leadership Team for Fire, he was Assistant Director for Forest Planning and Silviculture, in Forest Management for the Forest Service. In this position, he was responsible for the development of national policy, standards and guides for forest planning and Silviculture including reforestation, timber stand improvement, forest genetics, forest and land and resource management planning (FLRMP), and the National Environmental Policy Act (NEPA).

Since his retirement from Federal Service, he was the senior advisor and co-consultant for the Brookings Institution, Center for Public Policy Education managed project for Quadrennial Fire Review final report on the future of the national wildland fire program, released in January 2009. His work in international program assistance included a study completed for Portugal in 2004 as part of the USA/Portugal Wildfire Technical Exchange project. (He recently revisited Portugal in 2008 to present a follow-on assessment report at a national fire conference.)

He has a Bachelor of Science degree in Liberal Studies from Eastern Oregon University.

A. C. Hyde

Dr. Albert C. Hyde is currently an independent advisor and consultant working with government and non-profit organizations in strategic thinking and management innovation.

For the past 16 years, he managed the consulting services operation of the Brookings Institution's Center for Public Policy Education in Washington D.C. Over the last five years, he directed a series of major strategic innovation projects with the U.S. Forest Service and the Department of the Interior's fire agencies in wildland fire management to include:

The 2009 and 2005 Quadrennial Fire Reviews
The 2007 and 2006 Large Fire Cost Reviews
The 2008 and 2007 Mega-fire Model Studies for Fire Operations & Resource Planning
The 2004 Strategic Issues Panel for Wildfire Cost Containment

Earlier studies and consulting projects for federal wildland fire management agencies included human capital studies on training and development and workforce replacement, safety reviews of aerial fire management, and scenarios for strategic planning. Prior to his involvement with wildland fire management issues, his work with Brookings centered on business process reengineering and strategic planning consulting projects with the U.S. Customs Service, the National Library of Medicine, the Federal Aviation Administration, and the National Security Agency. In the 1980's, he had over a decade of private sector consulting experience in quality management and performance measurement with major petrochemical and engineering corporations in the United States and Europe.

Dr. Hyde also has an extensive academic background, having been a Visiting Professor at the American University's Department of Public Administration in Washington D.C. from 1992 to 1997. Prior to that, he was Director of the Policy and Public Management Departments at the University of Pittsburgh (1988-1991) and San Francisco State University (1984-1988) and Director of the Human Resources Management Program at the University of Houston-Clear Lake (1979-1984). Before going to academia, he was a senior associate with the New York State Legislative Commission on Expenditure Review and a Foreign Service Officer with U.S. State Department (1974-1978).

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