Home Office

Further Development of Risk Assessment Toolkits for the UK Fire Service

Technical Note – Risk Rating System for Vegetation, Large Heathland and Woodland Fires

March 2000

Entec UK Limited

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Report for

Kath Reynolds
FRDG, Home Office
Horseferry House
Dean Ryle St
London
SW1P 2AW

Main Contributors

Michael Wright
Paul Reaston
Karen Archer

Issued by

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Michael Wright

Approved by

....
Andrew Alder

Entec UK Limited

17 Angel Gate
City Road
London
EC1V 2SH
England

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1. Introduction

The purpose of this paper is to outline the approach taken to develop a simple risk rating system for major outdoor fires involving heathland, woodland/forestry, grassland etc, similar to that dealing with property fires. As part of this, guidance is offered on the level of economic and environment losses that may accrue following fires affecting forestry, agricultural crops and other areas of vegetation. It aims to identify areas with the potential for 'large' uncontrolled fires that may require more than 'normal' fire cover. It is assumed that 'normal' fire cover provided in other areas for dwellings etc. will be able to handle 'small' outdoor fires, although some allowance may be required where a high volume of outdoor fires impacts the availability of fire cover for other types of incidents. Also seasonal variations in fire risk are not explicitly considered as the method aims only to provide an indication of whether additional fire cover needs to be located (permanently) in an area.

This guidance is of a general nature and cannot be used to infer the actual losses that may accrue at any particular site. Such losses would inevitably reflect the unique combination of circumstances pertaining on an individual site including location, access, nature of use, national and local demand for the site and its productive capacity. The guidance is restricted to the losses that occur to crops/vegetation/woodland in the field and does not consider losses that may occur after any crops/output is harvested and in storage.

The subsequent sections of this paper address the following aspects:

- what types of vegetation may be affected;
- what is the extent of the vegetation type;
- the economic value of loss per hectare;
- the response time-loss relationship;
- how to incorporate grass etc fires into fire cover.

2. Type and Extent of Vegetation

According to the Countryside Survey conducted in 1990[1], the landcover of England, Scotland and Wales is broken up according to Table 1. Images of the ground were taken by satellites in space in conjunction with a field survey of 508 1 km squares. It was not aimed at any special interest such as agriculture, forestry or nature conservation. This survey provides a good source of vegetation type data for England, Wales and Scotland. It is also available on a GIS system that would allow integration with other data sets. For each vegetation type the total area, as a proportion of the total area, and a comment on combustibility are provided.

Table 2.1– Land cover of Great Britain from Satellite: the 17 key land cover types, Countryside Survey, 1990

Cover Type	Combustible Vegetation	England	Scotland	Wales	Great Britain	
		'000 km²	'000 km²	'000 km²	'000 km²	%
Urban	-	2.4	0.1	0.1	2.6	1.1
Suburban	-	11.1	1.3	0.6	13.2	5.5
Tilled land	Yes[2]	43.1	6.9	1.1	51.3	21.4
Managed grassland	No[3]	44.5	13.0	8.2	65.7	27.3
Rough grass/marsh	Yes	2.	1.7	0.7	4.3	1.8
Bracken	Yes	1.3	1.2	1.2	3.6	1.5
Moorland grass	Yes	7.6	10.7	2.	20.2	8.4
Open shrub heath/moor	Yes	2.3	24.0	1.5	27.9	11.6
Dense shrub heath/moor	Yes	1.2	5.4	0.6	7.2	3.0
Bog	No	0.3	3.8	0.2	4.3	1.8
Broadleaved/mixed wood	Yes	7.9	1.9	2.5	12.3	5.1
Coniferous wood	Yes	2.2	4.7	0.9	7.7	3.2
Bare ground	No	1.0	1.4	0.1	2.6	1.1
Saltmarsh	No	03	0.1	0.1	0.4	0.2
Beach/mudflats	No	0.7	0.6	0.1	1.4	0.6
Inland water	No	0.4	1.2	0.1	1.7	0.7

[1] DETR, 1993, "Countryside Survey, 1990, Summary Report"

[2] Tilled land is generally combustible except for root crops and horticulture.

[3] Managed grassland is generally not combustible, except for small areas cut for hay in extremely dry areas and small amounts of maritime vegetation.

Sea/estuary	No	1.9	5.2	0.6	7.7	3.2
Unclassified	-	3.1	1.9	1.1	6.1	2.6
Total Area	**-**	**133.7**	**85.0**	**21.6**	**240.2**	**100.0**
Land Area	**-**	**131.4**	**78.6**	**20.9**	**230.8**	**96.1**

Further analysis of the data indicates that in Great Britain around 97,900 km^2 (42%) is covered with vegetation that is combustible at certain times of the year. This is generally concentrated to the eastern and northern parts of the county in the arable and higher upland areas.

The situation in Northern Ireland is somewhat different with a much lower proportion of the vegetation cover being of the type that may burn. Some 75% of the farmed area is managed grass which will not be combustible with only around 4% in combustible arable crops and <1% in woodland. These latter items represent only around 50,000 ha of land (or 500 km^2) less than 1% of the Great Britain total.

3. Land Designations

In the UK various tracts of land are protected, this is denoted by various land classifications. Further, various areas are valuable as public amenities or tourist revenue. Information regarding these land classifications is available from Local Environment Agency Plan (LEAP) Documents and from the Countryside Agency's[4].

3.1 Local Environment Agency Plan (LEAP)

The LEAP is a consultation report, which identifies practical environmental issues, strategies and actions to secure environmental improvement. In a national context, the most important sites for nature conservation in the United Kingdom are protected as Sites of Special Scientific Interest (SSSIs) under the Wildlife and Countryside Act 1981. Some SSSIs are considered to of international importance and are designated as Special Protection Areas (SPAs) under the EC Birds Directive 79/409/EEC to protect important populations or species of birds. Alternatively, they can be put forward to the European Union as candidate Special Areas of Conservation (cSACs) under the new EC Habitats Directive 92/43/EEC to protect internationally important species and habitats. County Wildlife Sites (CWSs) are non-statutory areas identified as being important in a county or regional context.

The plan contains relevant information about the particular area including details of:

- an overview of the area, predominant land cover - grassland, moorland/heath, arable, urban/bare ground and woodland
- Environmentally Sensitive Areas (ESAs) as well as any extremely sensitive or contentious environment issues such as a particular species (flora and fauna) or topographical formations
- Special Areas of Conservation (cSACs), Special Protection Areas (SPAs), County Wildlife Sites (CWSs), Sites of Special Scientific Interest (SSSIs) and Ramsar sites
- Agriculture and Forestry Classification, Flood Defence and Coastal Protection

Other EU conventions, such as the Bonn Convention on the Conservation of Migratory Species of Wild Animals, form the basis of conservation agreements between countries. It is possible that by destroying a habitat of a migratory animal may severely jeopardise the survival of that species.

[4] http://www.countryside.gov.uk/

3.2 National Parks, AONB and Community Forests

The Countryside Agency maintains records of all National Parks, Community Forests and Areas of Outstanding Natural Beauty (AONB) in England. Figures 1, 2 and 3 illustrate the location of these designated areas, further details including names, sizes are contained in Appendix A.

Figure 3-1 - National Parks in England, see Table A.1 for further details.

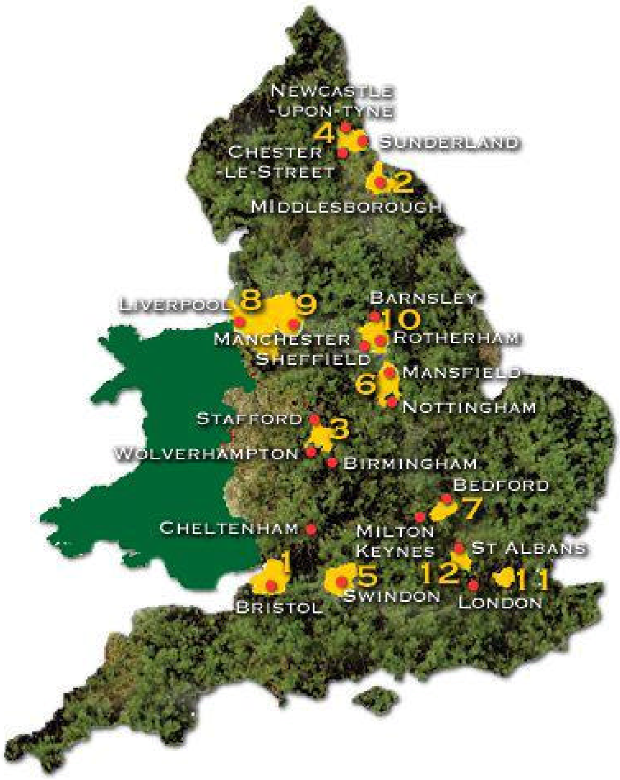


Figure 3-2 - Community Forests in England, see Table A.2 for further details.

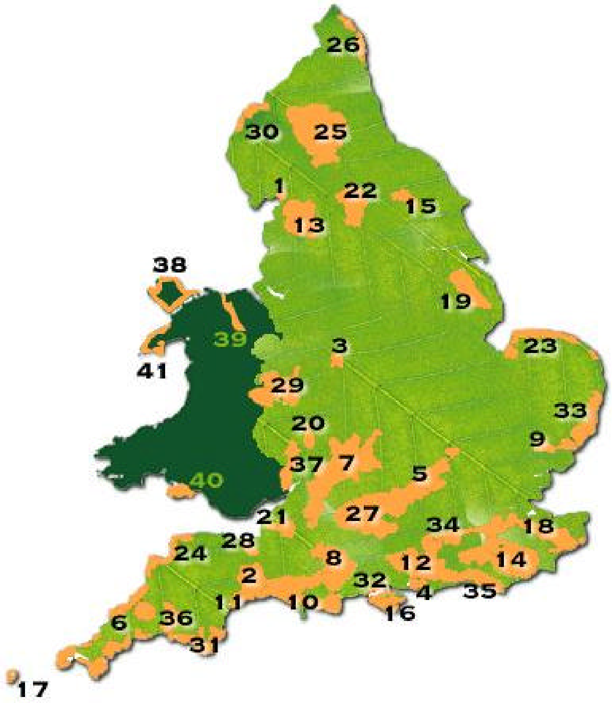


Figure 3-3 - Areas of Outstanding Natural Beauty (AONB) in England and Wales, see Table A.3 for further details.

3.3 Type and Scale of Environmental Losses

Environment losses include the loss of the vegetation which may act as a habitat for several different species of animals, birds, insects, etc. Combined with the loss of the vegetation itself, the wildlife or people dependent on the vegetation will also incur losses. This loss can be referred to as a direct but intangible loss of biodiversity. The impacts of these losses, on tourism for example, can be measured in terms of economics and are discussed in the following section.

Obviously, depending on the nature of the fire, and the specific nature of the vegetation the extent of damage or maximum damage will vary. By way of example, some roads and other discontinuities in forests will form a fire break and therefore restrict the spread of fire and therefore the maximum damage attainable. Thus large tracts of continuous forest are more at risk than those interspersed with secondary or larger roads.

4. Type and Value of Losses

4.1 Introduction

To fully assess the economic losses would require disaggregation of data to assess money flows within the agricultural industry to and from the Exchequer. The difference between the two data sets is likely to be relatively small and would in any case tend to reduce the apparent level of the economic losses. For the indicative purposes of this assessment, such additional detail is considered inappropriate and a simpler approach has been adopted.

It should be noted that financial losses to individual farmers or owners will be more significant. The types of loss that may occur as a result of fire include the following, fire fighting costs have been excluded.

Table 4.1 - Examples of Types of Loss as a Result of Fire

Classification of Loss	Type of Loss	Indicative Designations
Direct: - Tangible	Timber	
	Agricultural Produce	
	Sporting Income/Output	
Direct: - Intangible	Loss of Biodiversity	ESAs, SSSIs, SPAs, cSACs, SPAs, CWSs
Indirect: - Tangible	Tourism Revenue	National Parks, Community Forests, AONB

Each of these elements is discussed in turn.

4.2 Timber

There is considerable range in the nature of woodland within the UK from commercial coniferous plantations to newly established broad-leaved farm woodlands through to neglected amenity woodland. The former produces significant returns, whilst the latter may produce little more than a small amount of timber for the owner's heating purposes. Note that environmental considerations need to be taken into account as well. To illustrate the potential loss following fire a number of scenarios are described in Table 4.1.

Further statistics covering the loss, frequency and size of fires in state woodlands are contained in Appendix B. Analysis of Table B.5 details the average size of woodland fires over the last 8 years. The largest fires tend to occur in Scotland, with the average size being 60 ha (less than 1 km^2).

Table 4.1 - Potential loss following a fire

Scenario	Value £/ ha per event
Coniferous and Broad-leaved - Fire shortly after establishment	£2,000
Loss equates to the establishment costs incurred. It is assumed that replanting occurs and there is no loss of final output.	
Coniferous - Fire prior to final harvest	£4,000
Loss equates to Gross Margin (output less all growing and harvesting costs) plus harvesting costs saved). Earlier thinning outputs offset the costs of extracting the thinnings. A 40 year growing cycle is typical.	
Broad-leaved - Fire prior to final harvest	£8,000
As above but 120 year growing cycle.	

Taking a simple average of the establishment and harvesting loss indicates that the average loss of timber value per ha per event is £3,000 for coniferous woods and £5,000 for broad-leaved woods.

4.3 Agricultural Produce - Combinable Crops

Winter wheat is taken as an example to illustrate the approximate scale of the possible loss of agricultural crop from fire. This could be considered to be the most profitable of the combustible agricultural crops and therefore represents an upper limit on the value.

The loss of crop through fire is only likely to occur towards the end of the growing cycle after all costs, other than harvesting costs, have been incurred. The potential loss is therefore estimated as follows:

Table 4.1 - Potential loss following a fire

Scenario	Value £/ha
Total output (excludes area payments)	600
Less all growing costs of growing and harvesting the crop (excludes own labour/finance charges, etc)	500
Plus costs saved (i.e. harvesting costs not yet incurred)	100
Estimated Economic Loss £/ha Event	200 /ha/yr

As discussed above the financial loss (probably insured) for an individual farmer would be greater than this economic loss and would equate to the value of the output less any costs not yet incurred, in this instance £500 (£600 less £100).

4.4 Agricultural Produce - Moorland Grasses and Bracken/Other Heaths

For moorland grass and bracken and for other heaths (Table 2.1) there is also the potential for loss as a result of loss of grazing potential. Little research has been identified to assess the duration over which the effect may last. However, it is suggested that such damage could take up to five years before recovery occurred before grazing could resume at previous levels.

The potential loss incurred is considered most likely to be offset by farmers seeking additional grazing for livestock elsewhere or perhaps by increasing their use of fertiliser on other managed grassland. Economic losses, due to additional costs being incurred, are thought likely to be small in the order of £8/ha/yr for five years, a total of £40 per hectare per event.

4.4.1 Sporting Income

For some vegetation types, particularly heather moorlands, there may well be a loss of sporting income as a result of the loss of habitats for grouse, etc. The same may also be true for woodland and agricultural land though as the areas and values involved in these cases are very small, and considerable scope for transfer of shooting occurs, these losses are considered negligible and are ignored. For the current purposes an assessment will be made as if the land concerned was a grouse moor.

Controlled burning is an integral part of proper moorland management for grouse encouraging the regeneration of heather within one or two seasons. Uncontrolled burning, however, tends to be more destructive and can lead to destruction of the habitats if it is peat, such as in 1977 on the North Yorkshire Moors. Such extreme circumstances are not frequent and a more typical scenario is proposed for assessment. In this the regeneration takes some 10 to 15 years to effect and leads to the loss of sporting income over this period. An assumption is also made that none of this loss is substituted elsewhere.

There is little data available on grouse moor sales or rentals though reviews by Hooper and Whitby (1988) updated to current price levels suggest annual revenues for sale of birds and shooting rentals could be around £30/ha on commercial moors, though may be only £5 to £10/ha on moors not run on a commercial basis.

If it is assumed that no game keepering costs would be incurred over the regeneration period then this value represents the annual loss. Over the 10 to 15 year period of regeneration the total loss would be between £300/ha and £450/ha per event.

Clearly, in some very significant fire events where the habitat does not regenerate, the loss would continue in perpetuity, though in such instances some substitution/transfer of loss would occur to reduce the impact.

4.4.2 Loss of Biodiversity

The loss of faunal and floral life from areas of vegetation damaged by fire may not be significant for the biodiversity of an area if the extent of damage is small and remaining and adjacent populations are able to recolonise the affected area. However, in some instances such as on peat moors, the damage may be such as to effectively lead to the loss of the habitat. Whilst such circumstances may be few in their occurrence, they may be significant As a non-traded commodity the value of the biodiversity cannot readily be estimated. To address this limitation researchers have developed a number of methods including contingent valuation (CV) approaches.

A recent study for the Forestry Commission hints at the possible value of this loss using this CV approach. This study sought to identify how much the public valued the biodiversity of British Forests by an interview survey. This indicated that households were willing to pay in excess of £20 per household per annum to improve the management of forests to increase their biodiversity. With some 20m households in the UK this suggests a value in excess of £400m per annum, a scale of value which has led some to view the figures with some scepticism, preferring to use the data to indicate the public interest in this type of issue.

4.4.3 Impact on Tourism

In general terms, it is reasonable to assume that a fire leading to the loss of vegetation in an area visited for its scenic beauty by tourists may lead to a reduction of tourist expenditure in the area providing the extent of the area affected was significant. Table A.1 contains details regarding the estimated number of visitor days per year for each park indicating that revenue generated by tourism is significant. Converted to days per hectare yields a maximum of 178 days/ha/yr. Assuming the average visitor spends £50 per day, around £900 per hectare per year. However, whether this local loss arises at a national level or is offset by transfer of the expenditure to other areas is less clear.

For example, a large fire on the North Yorkshire Moors (NYM) may well mean that fewer visitors specifically visit the area affected. However, this forms a small part of the total NYM area and it is reasonable to conclude that the majority of the reduction would be offset by increases in other parts of the NYM. Clearly, if the whole NYM had been affected, then the transfer to other similar areas may have been incomplete resulting in some economic loss. The same incomplete transfer may occur where the area being visited is of a more unique nature, for example the New Forest. Again, however, it is suggested that a very significant area would need to be affected before there was an impact on the economic activity from tourism. The likelihood of any event at this scale is considered negligible.

4.5 Summary

The data noted above is summarised in Table 4.1.

Table 4.1 - Summary of Economic Losses

Description	Total Area[5] (Thousand km²)	Average Economic Loss (£ per ha per Event)
Forestry:		
• Coniferous	*13.7*	*3,000*
• Broad Leaved	*13.0*	*5,000*
Agriculture:		
• Combinable crops	*41.8*	*200*
• Moorland/Grasses/Other Heaths without sporting interest	*32.1*	*40*
• Moorland/Grasses/Other Heaths with Sporting interest All Managed	*3.5* [6]	*415*
• Grassland / horticulture and root crops/ other land	*127.5*	*0*

[5] Great Britain Only

[6] Area of managed moor.

5. Response Time-Loss Relationship

In order to quantify the benefit of intervention for outdoor fires, the relationship between the time taken to attend the fire and the extent of damage incurred by direct burning needs to be established.

5.1 FDR1 Data

FDR1 data includes information about woodland and grassland fires as identified within the 'Type of Property' code. Within FDR1 data, the area of damage by direct burning is represented by the 'Areaburn' field. A description of the ranges of areas covered by the FDR1 data and the distribution of Woodland and Grassland fire records from 1994 - 1998 is contained in Table 5.1. For example, FDR1 category 16 constitutes all fires which led to from 20 - 49 m^2 damage, from direct burning. In the period from 1994 - 1998 there were 51 woodland fires and 30 grassland fires which led to this extent of damage.

Table 5.1 - Distribution of Area of Damage (field AREABURN) data for Woodland and Grassland fires within FDR1 data from 1994 - 1998.

FDR1 value	FDR1 Range Description	Woodland Fires		Grassland Fires		All Fires	
11	< 1 m^2	12	1.7%	60	11.7%	72	5.9%
12	1 - 2 m^2	15	2.1%	22	4.3%	37	3.0%
13	3 - 4 m^2	26	3.7%	22	4.3%	48	3.9%
14	5 - 9 m^2	14	2.0%	17	3.3%	31	2.5%
15	10 - 19 m^2	26	3.7%	27	5.3%	53	4.3%
16	20 - 49 m^2	51	7.2%	30	5.8%	81	6.6%
17	50 - 99 m^2	41	5.8%	23	4.5%	64	5.3%
21	100 - 199 m^2	53	7.5%	25	4.9%	78	6.4%
22	200+ m^2	467	66.2%	288	56.0%	755	61.9%
		705	100.0%	514	100.0%	1,219	100.0%

The area categories stored within this data is biased towards smaller building or motor vehicle fires. As would be expected, the majority of woodland and grassland fires are large, 62% fall within the 200+ m^2 category. The actual extent of damage incurred in these fires is stored in an additional data field, 'AburnOth'. This information is crucial to the analysis but is only available for 1994 fire records, thereby significantly limiting the pool of data available for analysis.

5.2 Forest Enterprise Woodlands Fire Data

Appendix B details fire loss comparison statistics from the Forest Operations division of the Forestry Commission. The data covers the time period from 1991 to 1999. It includes details regarding the number of fires, the size of fires and loss incurred by these fires. The data covers state woodlands only, which vary in size from the New Forest (small) to Kielder Forest (large).

The frequency of fires varies owing to both seasonal variations and as a result of varying occurrences of arson in the forests from year to year. It is pertinent to view woodland fires in 1994 in the context of similar fires from 1991 to 1999. This Forest Enterprise data demonstrates that 1994 was a relatively fire-free year with around 50 fires that year, as compared to an average of 305 fires per year over 8 years. This does not preclude the use of this data for an initial attendance time - damage analysis, however the results must be considered with this in mind.

Table 5.1 - Number of Fires in Forest Enterprise Woodlands from 1991 to 1999, given by region.

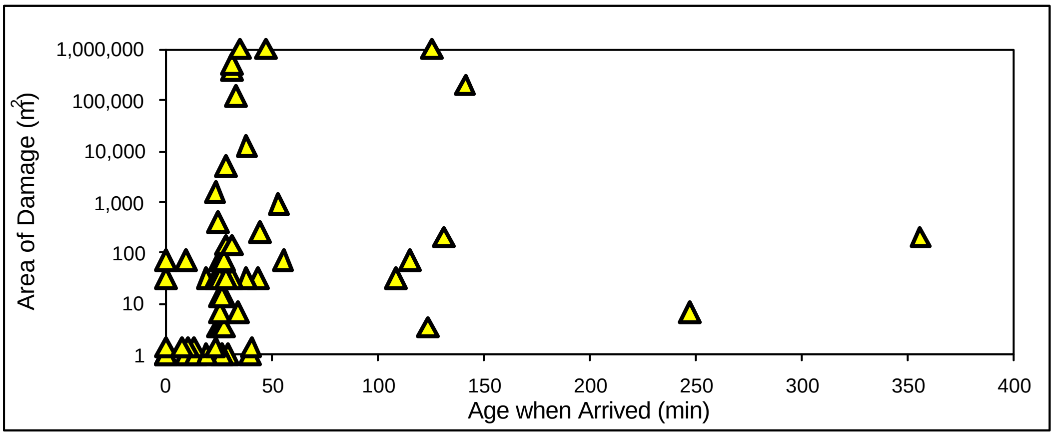
Region	1991/2	1992/3	1993/4	1994/5	1995/6	1996/7	1997/8	1998/9
N&E (E)	6	88	2	4	24	4	3	
S&W (E)		78	13	7	176	44	54	4
WALES	26	368	27	28	666	383	305	11
N(S)		8		3	6	5	3	0
S(S)	3	23	4	13	11	34	4	2
GB TOTAL	35	565	46	55	883	470	369	17

5.3 Damage - Attendance Time Relationship

For reasons stated earlier, only 1994 FDR1 damage data was used. Any spurious records were rejected, e.g. where no fire brigade intervention was required, or the data contained time anomalies. All time variables are considered to be from the time of ignition and are reported in units of minutes.

Owing to the typical location of large outdoor areas in rural areas, they are normally located further away from fire stations, thus leading to longer attendance times. Stated differently, a fire that is further away from the station is more likely to be a large plot of land with a large Maximum Probable Damage and it will take longer to arrive at the fire and will therefore take longer to control. This is a form of interdependency between the attendance time and the damage incurred. As a result of these interdependencies, there is no clear simple correlation between the age of the fire when attended and the area of damage incurred by direct burning, as illustrated in figure 5.1.

Figure 5.1 - Grassland Fires (1994 FDR1 data) - Typical Lack of Correlation



To strip out these interdependencies, the data was considered in terms of the 'age when controlled' and the 'age when arrived'. The 'age when controlled' is the time from ignition until the time when controlled and likewise the 'age when arrived' is the time from ignition until fire brigade attendance at the fire. A relationship between the 'area of damage' and the 'age when controlled' was established. This is coupled with a relationship between the 'age when controlled' and the 'age when arrived', which is illustrated in and Figure 5.3. A linear trend is clearly indicated on these figures with a good regression coefficient (R^2) above 0.85 (an R^2 of 1 represents a perfect fit). The 'banding' of data in and Figure 5.3 results from the grouping of area categories in the FDR1 database.

The strong correlation co-efficients (of 0.87 and 0.85) indicate a relationship does exist between the age of the fire when the brigade arrive and how long it takes to control it. This suggests that a faster response (all other things being equal) should lead to a faster control, and, presumably a smaller fire.

Figure 5.2 - Woodland Fires (1994 - 1998 FDR1 data)

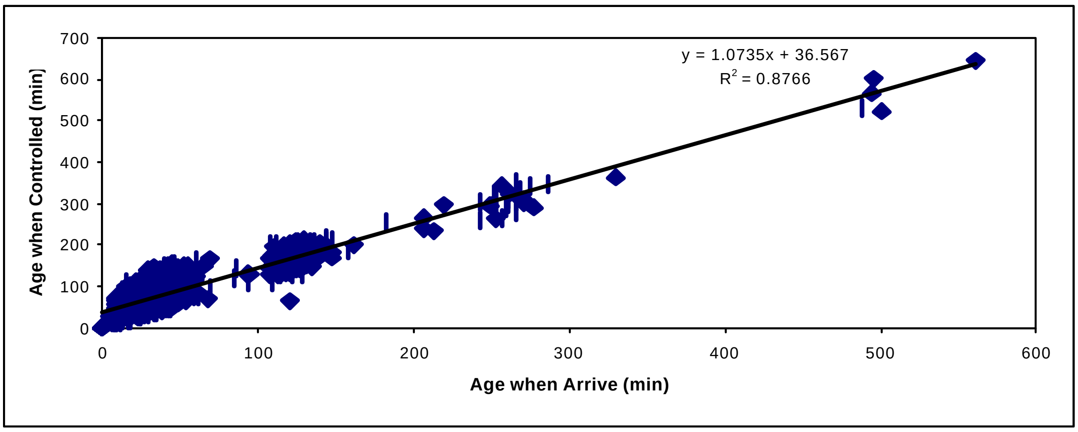
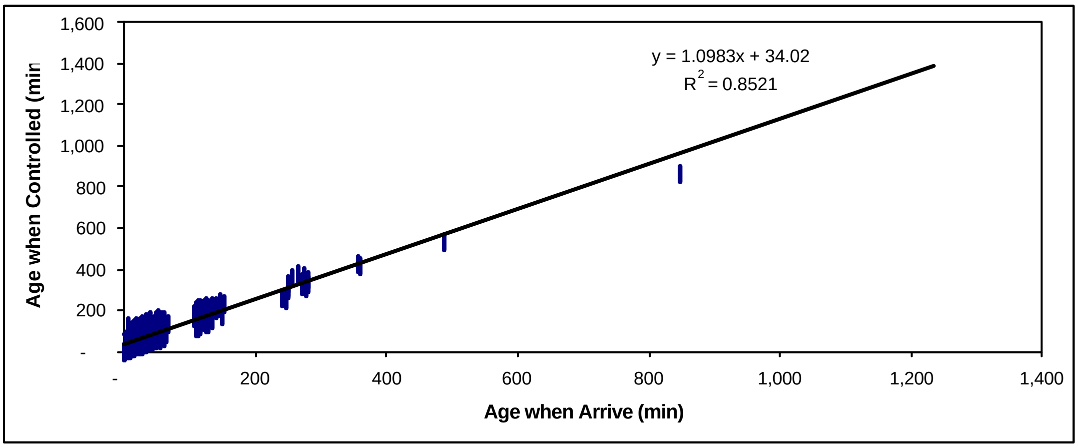


Figure 5.3 - Grassland Fires (1994 - 1998 FDR1 data)



Given the similarity of these linear equations, the same linear correlation can be used for both woodlands and grasslands fires:

grassland and woodland: $ctrl = arvl \times 1.09 + 34.6$

where *ctrl* is time to control fire from ignition (min) and *arvl* is time to arrive from ignition (min)

Close examination of this correlation shows that this is predicting a constant relationship between the time to control the fire (from attendance time) and the time to arrive at the fire (from ignition), as indicated by the slope of the graphs being approximately 1.

Considering the relationship between the 'area of damage' and the 'age when controlled', as illustrated in Figure 5.4 - Damage to Grasslands (1994 FDR1 data only)) and Figure 5.5 - Damage to Woodlands (1994 FDR1 data only)), completes the correlation. These relationships can be expressed according to:

grassland damage (m^2): $$Damage = \sqrt[0.07]{\frac{ctrl}{45.4}}$$

woodland damage (m^2): $$Damage = \sqrt[0.08]{\frac{ctrl}{46.2}}$$

This two-step correlation can be mathematically combined by simple substitution for ease of computation according to:

grassland damage (m^2): $$Damage = \sqrt[0.07]{\frac{arvl \times 1.09 + 34.6}{45.4}}$$

woodland damage (m^2): $$Damage = \sqrt[0.08]{\frac{arvl \times 1.09 + 34.6}{46.2}}$$

Thus, if the arrival time can be stated, it should be possible to predict the age of the fire when controlled. This "age when controlled" can then be used to estimate the size of the fire.

Figure 5.4 - Damage to Grasslands (1994 FDR1 data only))

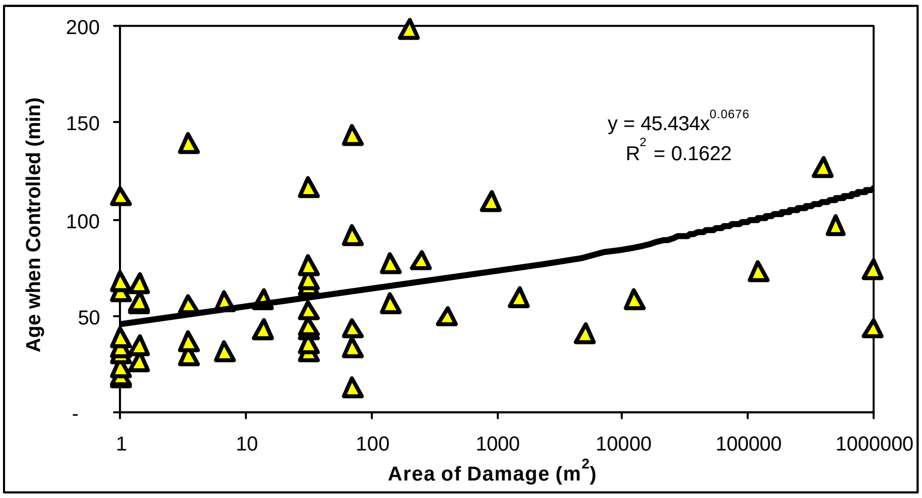
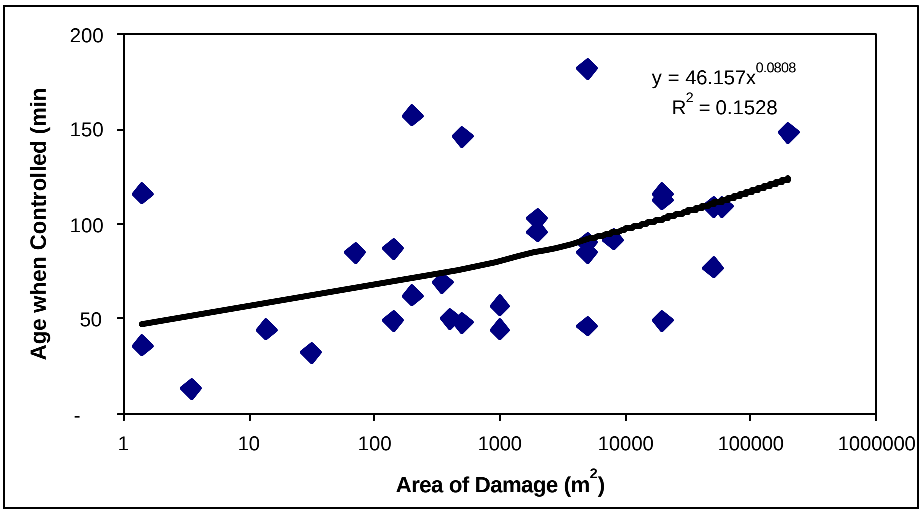


Figure 5.5 - Damage to Woodlands (1994 FDR1 data only))



The relatively poor correlation ($R^2 < 0.2$) between 'age when controlled' and 'area of damage' can be attributed to the lack of relevant data, as described previously. In fact the analyses are based on 23 FDR1 records (187 fires) for Woodlands and 20 FDR1 records (38 fires) for Grasslands.

This low correlation and small data set must be acknowledged as a source of uncertainty regarding the validility of the relationship

6. Possible Fire Cover Model

The next question is how may this model be applied to fire cover modelling?

Whilst the benefit of intervention may well include human lives saved as well as the limitation of either a loss of product, trade or vegetation and wildlife, it is proposed to limit consideration to non-safety benefits as they comprise the predominant risk. These benefits are summarised in Table 4.4.

Drawing on the consideration of the nominal value of heathland etc and the response-time-loss model, a five step method can be used for calculating the loss for a given response time, as follows:

1. Estimate attendance time ‘arvl’ (min) based on proposed or actual distance from fire station to area of concern.
2. Estimate control time ‘ctrl’ (min) from expression illustrated in Figure 5.3.
3. Estimate area of damage (m^2) using expressions illustrated in Figures 5.4 and 5.5.
4. Associate damage (m^2) with appropriate economic losses by application of values in Table 4.4.
5. Multiply the product of 4 by the average number of such fires per annum in the area of concern.

The benefit of arriving sooner would be given by the difference in extent of fire damage. This could be compared against the marginal costs of arriving sooner.

In the event that the area has a special status, such as an area of outstanding natural beauty or a site of special scientific interest, a multiplier of (say) 2 to 3 could be applied to the per hectare value of heathland etc. The level of loss should be “capped” by the estimated maximum probable loss. This would be the size of land across which an uncontrolled fire could spread if there was no fire brigade intervention. This could mean the maximum size of fire may be limited by fire breaks, roads, rivers etc or encompass on entire forest.

An example

Assuming it takes 60 minutes to arrive at a **woodland** fire after ignition, the fire will be controlled after 100 minutes with 15,558 m^2 or 1.6 ha of damage. This would incur a total loss in the region of £7,800. If it took 45 minutes to arrive at the same fire, the fire would be controlled within 84 minutes incurring m^2 or 1,760 m^2 or 0.18 ha. This corresponds to £900 of loss. Thus the reduction in the time to arrive reduced the estimated loss by £6,900. So, if there were 10 such fires per year in an area, the 15 minute reduction in response times would give £69,000 of savings. For this approach to be applied, brigades would need to estimate how many uncontrolled fires occur each year on average and then look at the cost benefit of different response times. It is suggested that the average is based on least three years of experience.

It is also suggested that consideration is restricted to outdoor fires reported on FDRIs (i.e. those requiring a sizeable response) as we are mainly concerned with establishing the need for additional resources over and above those needed for fires in buildings and special services.

7. Discussion and Conclusions

This study set out to develop a method for factoring outdoor woodland/grassland fires into fire cover modelling. A set of data has been used to derive a response time - loss model that produces a financial estimate of loss for a given response time. However, due to the current restrictions on the coding of fire size on FDRI forms, there is a very limited data set. It must be acknowledged that the small size of the validality of the response time - loss relationship.

Three options have been considered regarding the way forward, namely;

1. Apply the current model and data set to the pathfinder projects, with an aim to further develop and review the method and data at a future date when more information is available.
2. Acquire more data and re-analyse it now before piloting the method.
3. Devise another method that does not rely on the same data.

Due to the absence of additional data or an alternative method at this moment, it is proposed that the current method is applied within the scope of the pathfinder projects. In particular, it is proposed that:

- small outdoor fires (i.e. those recorded as FDR3 fires) are included in the fire cover modelling phase of assessment as a "volume" effect, i.e. does the volume of calls to FDR3 fires impinge significantly on the availability of fire cover for dwelling, other building fires and life risk special services?
- The data and time-loss relationship developed here be applied within the pathfinder brigade trials to those fires classed as FDR1 fires, using local fire brigade records to calculate the number of such fires per year in the study area. The decision regarding whether any additional fire cover is required for FDR1 outdoor fires should be based on a cost-benefit analysis as per other non-life risks in other buildings, i.e. does the value of averted losses exceed the cost of providing the additional resources?

It must be acknowledged that the time-loss model is based on a very small number of data points, due to the current coding of fire sizes on the FDR1 form. Ideally, further data would be acquired on fires that exceed $200m^2$ and the time-loss model be re-analysed, before the model is used beyond the pathfinder projects. This may entail revising the FDR1 form to allow a more discriminating coding of outdoor fire sizes.

Appendix A
Designated Areas

4 Pages

Tables A.1 - A.3 contain details of National Parks, Community Forests and Areas of Outstanding National Beauty. They are based on information from the Countryside Agency web site, which can be found at http://www.countryside.gov.uk/.

A useful conversion, in the context of the rest of the report is as follows:

$$100 \text{ m} \times 100 \text{ m} = 10^4 \text{ m}^2 = 10^{-2} \text{ km}^2 = 1 \text{ hectare (ha)}$$

Table A.1 – National Parks in England

National Park	Established (year)	Area (km^2)	Population (1991)	Visitors Days (million/yr)(1994)
1. The Broads	1989	303	6,050	5.4
2. Dartmoor	1951	954	32,231	3.8
3. Exmoor	1954	693	12,160	1.4
4. Lake District	1951	2,292	43,180	13.9
5. The New Forest	1990 +	578	35,000	6.6
6. Northumberland	1956	1,049	4,040	1.4
7. North York Moors	1952	1,436	26,524	7.8
8. Peak District	1951	1,438	43,266	12.4
9. Yorkshire Dales	1954	1,769	19,220	8.3

Table A.2 – Community Forests

Key	Community Forest	Area (km^2)	Existing Tree Cover	Population within 20 km (millions)
1.	Forest of Avon	573	5.9	1.0
2.	The Tees Forest	255	6.9	1.0
3.	Forest of Mercia (South Staffs)	210	6.4	4.0
4.	The Great North Forest (South Tyne & Wear/North East Durham)	160	8.0	1.0
5.	Great Western (Swindon)	390	3.0	0.3
6.	The Greenwood (Nottingham)	414	11.3	1.0
7.	Marston Vale (Bedford)	158	3.6	0.5
8.	The Mersey Forest	925	4.0	5.0
9.	Red Rose Forest tr Manchester West)	760	3.9	4.0
10.	South Yorkshire	395	7.6	1.9
11.	Thames Chase (East of London)	98	9.7	3.0
12.	Watling Chase (South Herts/North London)	163	7.9	3.0
	TOTAL			25.7

Table A.3 – Areas of Outstanding Natural Beauty

Key	AONB	Confirmation of order	Area (km^2)
	Gower	10 December 1956	188
	Quantock Hills	1 January 1957	99
	Lleyn	28 May 1957	161
	Northumberland Coast	21 March 1958	135
	Surrey Hills	8 May 1958	419
	Cannock Chase	16 September 1958	68
	Shropshire Hills	11 March 1959	804
	Dorset	29 July 1959	1,129
	Malvern Hills	22 October 1959	105
	Cornwall Camel Estuary (Extension to Cornwall)	25 November 1959 28 October 1983	958
	North Devon	25 May 1960	171
	South Devon	2 August 1962	337
	East Hampshire	26 September 1962	383
	East Devon	20 September 1963	268
	Isle of Wight	20 September 1963	189
	Chichester Harbour	4 February 1964	74
	Forest of Bowland	10 February 1964	802
	Solway Coast	12 December 1964	115
	Chilterns boundary variation	16 December 1965 14 March 1990	833
	Sussex Downs	7 April 1966	983
	Cotwolds boundary variation	19 August 1966 21 December 1990	2,038
	Anglesey	13 November 1967	221
	South Hampshire Coast	18 December 1967	77
	Norfolk Coast	8 April 1968	451
	Kent Downs	23 July 1968	878
	Suffolk Coast and Heaths	4 March 1970	403
	Dedham Vale first boundary variation second boundary variation	20 May 1970 21 August 1978 19 September 1991	90
	Wye Valley	13 December 1971	326
	North Wessex Downs	1 December 1972	1,730
	Mendip Hills boundary variation	1 December 1972 5 October 1989	198
	Arnside and Silverdale	15 December 1972	75

Key	AONB	Confirmation of order	Area (km^2)
	Lincolnshire Wolds	17 April 1973	558
	Isles of Scilly	18 February 1976	16
	High Weald	28 October 1983	1,460
	Cranborne Chase and West Wiltshire Downs	28 October 1983	983
	Clwydian Range	24 July 1985	157
	Howardian Hills	19 October 1987	204
	North Pennines	7 June 1988	1,983
	Blackdown Hills	26 June 1991	370
	Nidderdale	14 February 1994	603
	Tamar Valley	30 August 1995	195
	TOTAL AREA		21, 237

Appendix B
Fire Loss Comparison for Forestry Enterprise Woodlands

2 Pages

Tables B.1 to B.6 detail fire loss comparison statistics from the Forest Operations division of the Forestry Commission. The data includes the number of fires, size of fires and loss incurred by fires during the period from 1991 to 1999. The frequency of fire varies not only owing to seasonal variations from year to year, but also as a result of the varying occurrences of arson in the forests from year to year. The data covers state woodlands only, which vary in size from the New Forest (small) to Kielder Forest (large).

Table B.1 Number of Fires in Forest Enterprise Woodlands 1991 to 1999, given by region.

Region	1991/2	1992/3	1993/4	1994/5	1995/6	1996/7	1997/8	1998/9
N&E (E)	6	88	2	4	24	4	3	
S&W (E)		78	13	7	176	44	54	4
WALES	26	368	27	28	666	383	305	11
N(S)		8		3	6	5	3	0
S(S)	3	23	4	13	11	34	4	2
GB TOTAL	35	565	46	55	883	470	369	17

Table B.2 Area (ha) of Fires in Forest Enterprise Woodlands 1991 to 1999, given by region.

Region	1991/2	1992/3	1993/4	1994/5	1995/6	1996/7	1997/8	1998/9
N&E (E)	9.15	2.2	16	7.3	59.6	14.4	18.5	
S&W (E)		40.6	3.9	86.7	90.4	41	54.3	7.1
WALES	81.7	149	86.9	144	233	189	148.3	33.4
N(S)		1.6		170	3.38	41.4	45.4	0
S(S)	19.2	1.4	16.5	615	79.8	164	43.5	1.5
GB TOTAL	110.05	194.8	123.3	1023	466.18	449.8	310	42
% area	0.012	0.022	0.014	0.119	0.055	0.053	0.036	0.005

Table B.3 Loss (£) from Fires in Forest Enterprise Woodlands 1991 to 1999, given by region.

Region	1991/2	1992/3	1993/4	1994/5	1995/6	1996/7	1997/8	1998/9
N&E (E)	17759	7000	32100	1600	13792	6591	1780	
S&W (E)		42000	600	30150	74270	42251	18758	5035
WALES	96285	119000	55200	113520	180720	147200	115850	36500
N(S)		7000		103120	1191	40450	101225	0
S(S)	24971	3000	15606	580128	80235	101000	36035	0
GB TOTAL	139015	178000	103506	828518	350208	337492	273648	41535

Table B.4 Loss (£) per Fire in Forest Enterprise Woodlands 1991 to 1999, given by region.

Region	1991/2	1992/3	1993/4	1994/5	1995/6	1996/7	1997/8	1998/9
N&E (E)	2,960	80	16,050	400	580	1,650	600	
S&W (E)		540	50	4,310	430	970	350	1,260
WALES	3,710	330	2,050	4,060	280	390	380	3,320
N(S)		880		34,380	200	8,090	33,750	
S(S)	8,330	140	3,910	44,630	7,300	2,980	9,010	0
GB Average	5,000	394	5,515	17,556	1,758	2,816	8,818	1,527

Table B.5 Average size (ha) of Fire in Forest Enterprise Woodlands 1991 to 1999, given by region.

Region	1991/2	1992/3	1993/4	1994/5	1995/6	1996/7	1997/8	1998/9
N&E (E)	2	1	8	2	3	4	7	
S&W (E)		1	1	13	1	1	2	2
WALES	4	1	4	6	1	1	1	4
N(S)		1		57	1	9	16	
S(S)	7	1	5	48	8	5	11	1
GB Average	4	1	5	25	3	4	7	2

Table B.6 Loss (£) per hectare of Fire in Forest Enterprise Woodlands 1991 to 1999, given by region.

Region	1991/2	1992/3	1993/4	1994/5	1995/6	1996/7	1997/8	1998/9
N&E (E)	1,941	3,182	2,007	220	232	458	97	
S&W (E)		1,035	154	348	822	1,031	346	710
WALES	1,179	799	636	789	776	779	782	1,093
N(S)		4,375		607	353	978	2,230	
S(S)	1,301	2,143	946	944	1,006	616	829	0
GB Average	1,474	2,307	936	582	638	772	857	601