EXTREME VALUE ANALYSIS IN DETERMINING ANNUAL PROBABILITY OF EXCEEDANCE FOR BUSHFIRE PROTECTION.

Grahame Douglas[1]

[1] School of Computing, Engineering and Mathematics, University of Western Sydney, NSW

Introduction: While wildland fires (bushfires) are an anticipated event with each fire season, it is important that the extent of likely annual fire weather conditions and those of more extreme conditions are identified as part of community preparations for fire season. Historically extreme value analysis has been used for floods, storms, temperature, and wind, however, little work has been produced for extreme fire weather. This may be because historically a fire weather index is a composite of differing weather conditions, which, at their extreme, individually may not be related to wildland fire alone. Fire danger index systems generate non-dimensional parameters and in Australia, this has generally focussed on the forest fire danger index or grassland fire danger index.

While it is difficult to ascertain individual extremes related to individual parameters for wildland fire, the use of the Generalised Extreme Values distribution is a suitable process for fire danger indices. This can be applied to deterministic fire behaviour assessments whether through the identification of rate of spread, flame length, intensity or suppression effort.

Treatment options for existing homes can be more effectively determined and quantified under such an approach so as to better balance resident and fire fighter safety as well as recognizing environmental assets.

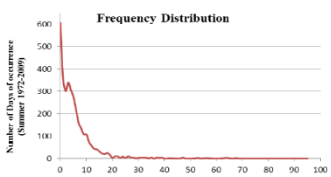

Figure 1:Sydney FFDI frequency distribution

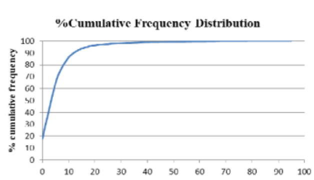

Figure 2:Sydney FFDI % cumulative frequency distribution.

The frequency distribution and cumulative distribution curves of a single site (Sydney Airport) are shown in Figures 1 and 2 respectively. Maximum FFDI recorded is 99 over a 36 year period, however, this provides little information as to the likelihood of extreme events into the future. Figure 3 and 4 show the relationship of summer KBDI and FFDI over the record of data for Sydney airport, suggesting that drought is driving FFDI through pre-conditioning rather than other climatic factors.

Methodology: This study uses a generalised extreme values approach (Makkonen, 2006), which is assessed based on the inclusion of a minimum of n +1 years of data points.

The GEV distribution uses the equation T= (N + 1)/M where: T = return period (recurrence), N= no of years of data and M = rank value.

An Excel spreadsheet was used to determine rank values for the FFDI values to and in some cases below the 1:1 year outcomes. The resultant plot was then subject to a log linear graph and the resultant line of best fit and correlation (using r^2) determined. The resultant curve will follow the form y = a log(x) + b.

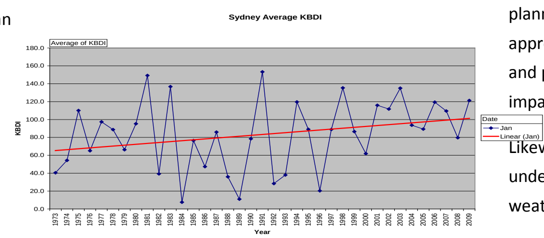

Figure 3: Sydney Average January KBDI 1972-2009 with trend line.

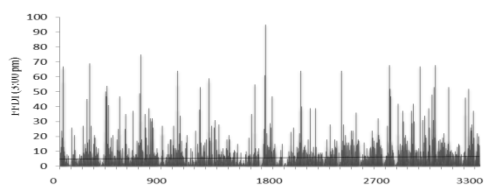

Figure 4: FFDI summer days 1972-2009.

Results. Ten (10) NSW weather station datasets were provided by the Bureau of Meteorology, comprising part of a National Fire Weather dataset (Lucas, 2010). Data is for FFDI based on1500hrs for wind speed and humidity, daily drought factors and maximum temperature as a surrogate for maximum FFDI.

The GEV and regression analyses were applied to all 10 selected weather stations and the results are presented in Table 1. Also included in Table 1 are the FFDI values corresponding to 1:50 and 1:100 return periods in comparison with the maximum FFDI obtained from the record and the NSW policy FFDI values.

Weather Station	*a*	*b*	r^2	FFDI			
				R=1:50	*R*=1:100	Max	AS3959
Sydney Airport	11.089	54.134	0.9842	98	105	95	100
Richmond	13.196	59.913	0.9728	112	121	96	100
Williamtown	13.227	54.672	0.9823	106	116	99	100
Coffs Harbour	18.226	24.299	0.9722	96	108	95	80
Casino	13.73	65.802	0.9424	120	129	101	80
Canberra	12.212	51.752	0.9564	100	108	99	100
Wagga Wagga	13.606	68.717	0.9753	122	131	138	80
Nowra	15.973	49.854	0.9489	112	123	120	100
Dubbo	13.156	55.728	0.9871	107	116	99	80
Moree	16.937	48.961	0.9227	115	127	125	80

Table 1: Regression values (*a* and *b*), correlation co-efficients (r^2), and comparative FFDI values for return periods of 1:50 yr, 1:100 yr, maximum recorded value and NSW Policy values for 10 NSW weather stations.

Discussion. GEV analysis is a suitable technique for determining FFDI for bushfire protection under planning and construction practice. It is a preferred approach than reliance on frequency distribution and percentile analysis which underestimates the impact of bushfire on properties (see Figure 2).

Likewise the use of maximum recorded FFDI may underestimate or overestimate the impact of fire weather conditions.

The correlation co-efficient r^2 for each line of fit is very high, illustrating the good agreement between the theory and the obtained FFDI *vs* return period relationship. Therefore, the theory can be applied with a high level of confidence to obtain FFDI of return periods beyond the data collection period.

References.

Lucas C. (2010) On developing a historical fire weather dataset for Australia. Aust. J. Meteorology and Oceanography, Vol.60, pp1-14.

Makkonen L. (2006) Plotting Positions in Extreme Value Analysis. J. of Applied Meteorology and Climatology.