The Role of Extreme Value Analysis to Enhance Defendable Space for Construction Practice and Planning in Bushfire Prone Environments

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Bushfire Problem

- Bushfires have complex temporal and spatial components:
  - Vegetation, Topography, Prevailing weather.
  - Not uniform across the landscape.
- Getting the correct inputs for fire behaviour to determine an engineered solution for construction and planning outcomes.
- Design bushfire impacts on cost of construction and risk of loss of life and property.
- Bushfires are a regular occurrence however not previously investigated for recurrence unlike floods and other natural disasters.

Towards a Design Bushfire

- BAL used as expression of radiant heat (plus flame and ember).
- Derived from flame dimensions, flame temperature and distance of receiver.
- FFDI linked to increased recurrence of fires as extreme events.
- Difficulty is defining bushfire scenarios for design and assessment purposes.
- Challenge as to appropriate FFDI as a benchmark or if a unified benchmark exists?
- Verification method being introduced to BCA.

Recent Major Bushfire Events

Event	Year	FFDI	Source
Ash Wednesday	1983	>100	Sullivan (2004)
Mt Hall fire	2001	>100	NSW RFS (2002)
ACT (Duffy, etc.)	2003	105	McLeod (2005)
Eyre Peninsula	2005	200	Smith (2005)
Black Sunday	2009	188	VRCB (2010)

Challenges

- Climate change and use of GCM
- Previous studies focussed on historical data.
- Mapping of extreme values and return periods:
  - Relies on complex models
  - Use of FFDI vs inputs to FFDI?
  - Number of data points may be limited.
  - Scenarios occur at different periods in the landscape which climate models have difficulties.
- Alternatively, build up weather station data.

Fire Behaviour Models

- McArthur vs Vesta
- Underpins site assessment – flame dimensions
- Sensitive to underlying assumptions.
  - Weather
  - Vegetation
- FFDI applied to National Fire Weather Dataset (Lucas, 2010) but limited locations.
- ENSO – IOD affects?
- Models require different inputs.

Data Collection and Analysis

- National Historical Fire Weather database and other data can be used for robust assessment.
- NSW has 21 fire weather areas (districts)
- Additional FFDI datasets derived from BoM data.
- Some areas FFDI not appropriate (Far Western NSW).
- Composite of National Historical and new Datasets used.

NSW Fire Weather Areas

1	Far North Coast	Grafton
2	North Coast	Coffs Harbour
3	Greater Hunter	Williamtown
4	Greater Sydney	Sydney
5	Illawarra/Shoalhaven	Nowra
6	Far South Coast	Batemans Bay
7	Monaro-Alpine	Cooma
8	ACT	Canberra
9	Southern Ranges	Goulburn
10	Central Ranges	Bathurst
11	New England	Armidale
12	Northern Ranges	Tamworth
13	North-Western	Moree
14	Upper Central West	Coonamble
15	Lower Central West	Dubbo
16	Southern Slopes	Young
17	Eastern Riverina	Wagga Wagga
18	Southern Riverina	Deniliquin
19	Northern Riverina	Hay
20	South Western	Mildura
21	Far Western	Cobar

FFDI datasets

- Derived from:
  - 3:00 pm RH
  - 3:00 pm Wind speed (@10m)
  - Maximum daily temperature (Celsius)
  - Daily Drought Factor (DF)
  - 1976-2009 (Lucas, 2010) and 1994-2009 BoM
- Forest Fuel Moisture:
  - Vesta (Temp and RH) @ 3:00 pm.
- Wind speed (Vesta) @ 3:00 pm.
- Not all Lucas (2010) data used.

Past approaches

- FFDI exceeded on more than one occasion
- FFDI which has a frequency percentile value.
- Derived value from maximum of input values (i.e. RH, Wind, DF, and Temp.)

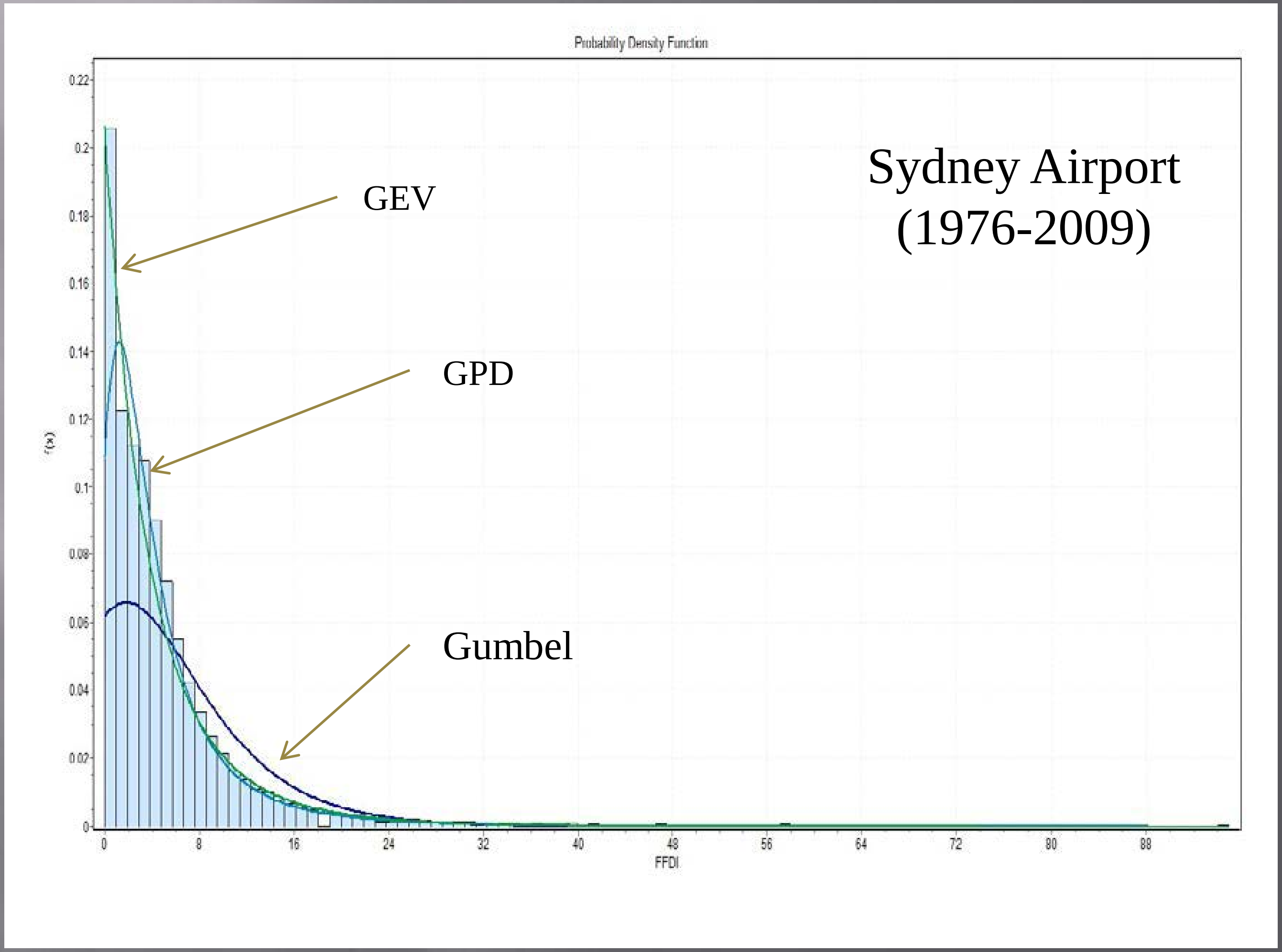
- Each has significant shortfalls.

- Based on limited past records.

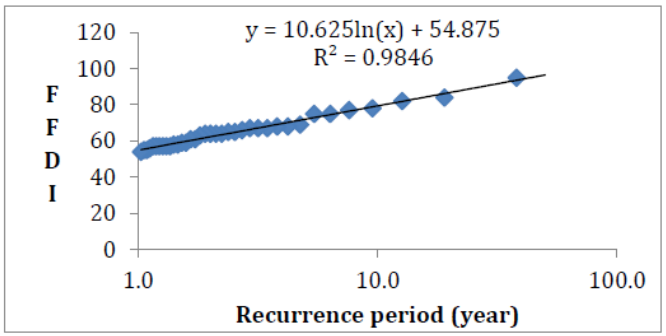
Extreme Value Assessments

- Current study considers FFDI and FMC.
- Three techniques considered:
  - GEV
  - GPD
  - Classical Gumbell (annual max)
- All three techniques and the associated distributions were tested for fit and correlation coefficient.
- 1:50 year return (recurrence or ARI) determined.

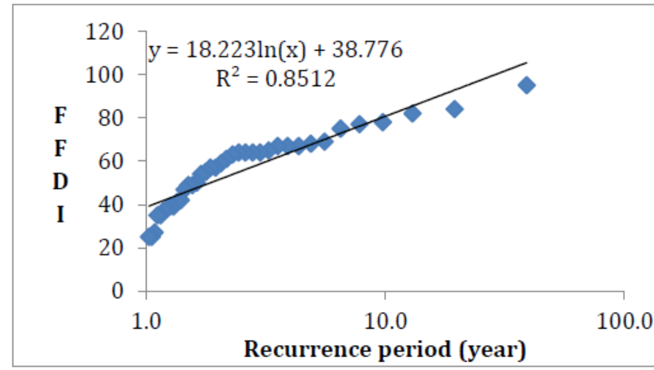
Probability Density Distribution



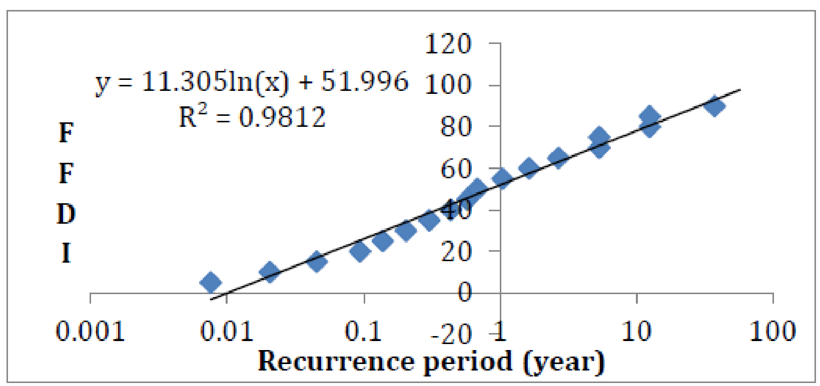
Recurrence Plots for Sydney Airport



(a) Results of GEV method.



(b) Results of Amax method.



(c) Results of GPD method.

District No.	FFDI$_{1:50}$			FFDI		Fm$_{1:50}$ (%)
	GEV	A_{max}	GPD	AS3959	3:00pm Max	GEV
1	101	120	94	80	93	2.64
2	96	94	82	80	95	2.86
3	106	121	101	100	99	1.84*
4	98	110	96	100	95	2.47
5	112	122	104	100	120	3.55
6	97	112	90	100	74	3.07
7	83	96	84	80	68	2.28
8	100	115	96	100	99	2.48
9	105	121	104	100	91	2.00
10	83	100	82	80	91	2.93
11	46	52	46	80	46	3.07
12	100	101	100	80	105	2.44
13	115	104	103	80	125	2.41
14	123	163	121	80	121	2.29
15	107	121	101	80	99	2.60
16	79	97	89	80	71	2.35
17	122	144	121	80	138	2.26
18	131	146	125	80	121	2.42
19	108	125	106	80	125	1.55*
20	136	150	130	80	132	2.40
21	116	128	113	80	117	2.22

Discussion

- Extreme value techniques allow interrogation of multiple weather parameters.
- GEV preferred tool and feasible for risk determination.
- GPD generally closer than Amax. Amax generally higher than GPD or GEV.
- GEV is more flexible with data limitations.
- Generally FFDI 100 for NSW but some exceptions.
- Can be used for FMC (but limitations).

Summary and Conclusions

- Bushfire behaviour models need good data for planning and construction practice.
- Previously applied approaches have shortfalls.
- Mapping processes have limitations for planning and construction practice.
- EVA used in current study has overcome shortfalls of other methods. It sets a scientific foundation for determining design bushfire conditions.
- GEV method preferred and shows good correlation with the field data.

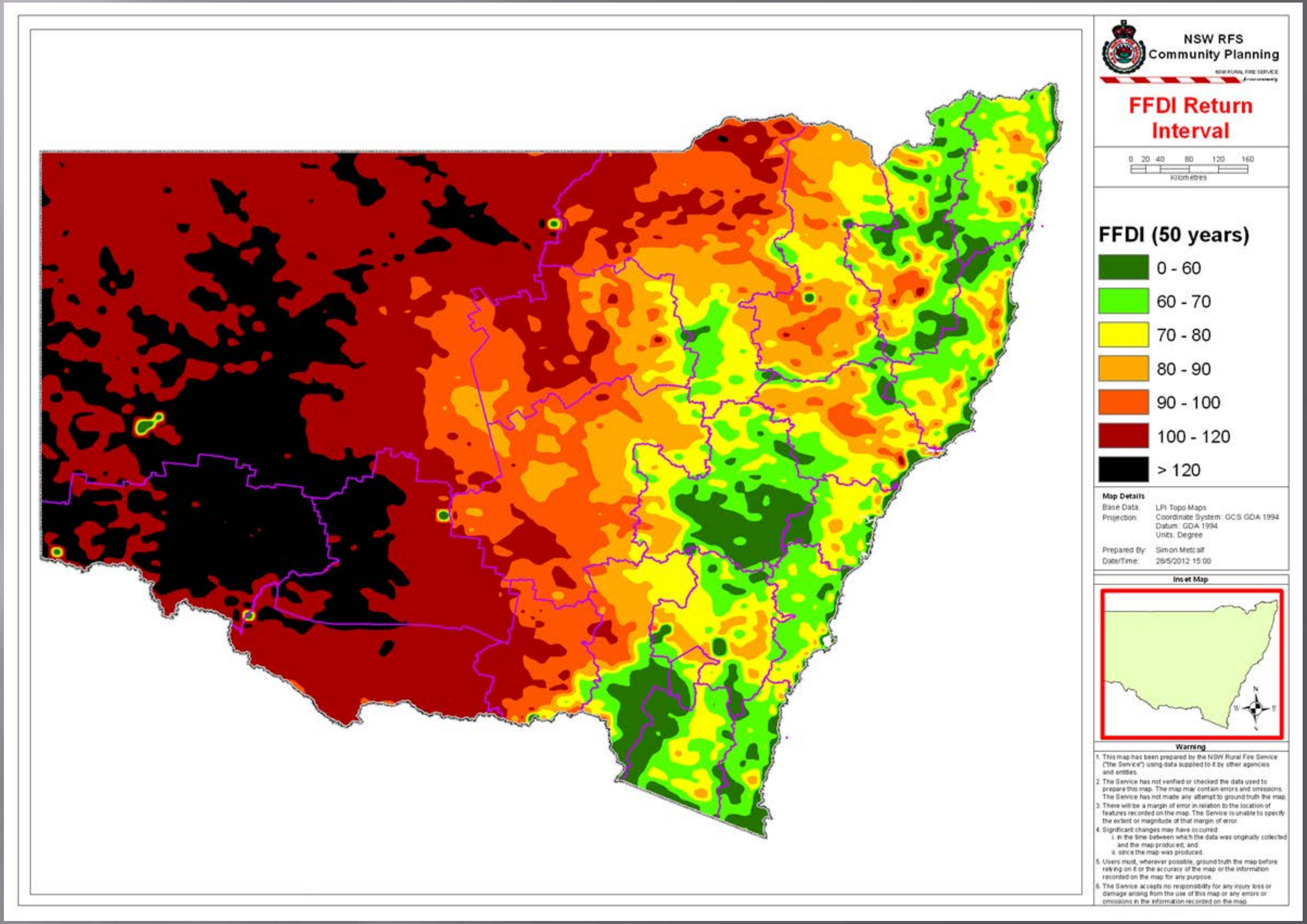
Future Work

- Same method can be applied to wind data in conjunction with fuel moisture for Project Vesta model
- The defendable space tables in the relevant standard can be revised based on the regional fire weather conditions and fuel characteristics
- Comparative evaluation of MacArthur and Project Vesta models at comparable return period

Acknowledgements

- Bushfire & Natural Hazards CRC
- NSW Rural Fire Service
- Bureau of Meteorology

Questions


NSW RFS
Community Planning
FFDI Return Interval
0 20 40 80 120 160
Kilometres
FFDI (50 years)
0 - 60
60 - 70
70 - 80
80 - 90
90 - 100
100 - 120
> 120
Map Details
Base Data: LPI Topo Maps
Projection: Coordinate System: GCS GDA 1994
Datum: GDA 1994
Units: Degree
Prepared By: Simon Metcalf
Date/Time: 28/5/2012 15:00
Inset Map
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