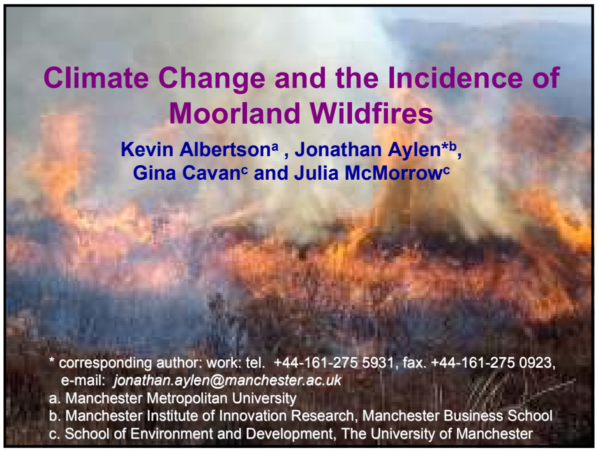

Climate Change and the Incidence of Moorland Wildfires

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Climate Change and the Incidence of Moorland Wildfires

Outline of discussion

- The Peak District National Park
- Incidence & Cost of Fires
- The Great Summer of '76
- Climate Change
- BETWIXT Climate Forecasts
- The Forecasting Model
- Visions From Our Smokey Crystal Ball
- Implications and Conclusions

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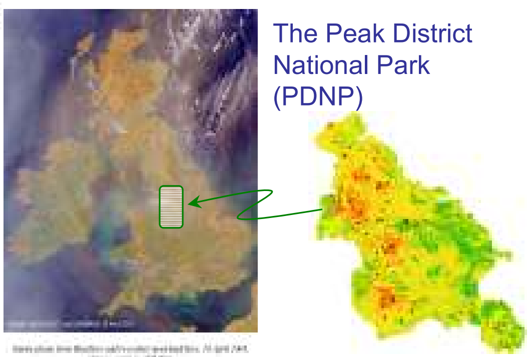
The Peak District National Park (PDNP)



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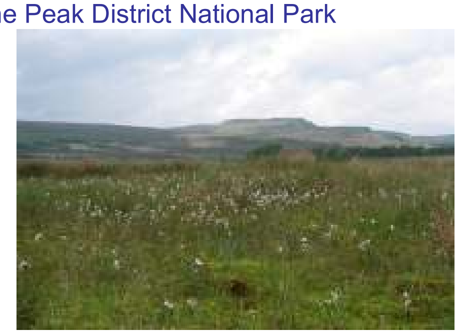
The Peak District National Park



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The Peak District National Park

- One of the most visited national parks – not just in the United Kingdom but in the world – second only to Mount Fuji in Japan.
- To the east, the Peak District National park is accessible to over 6 million people within an hours drive, (this usually occurs on either May bank holiday or the second week in August)

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Incidence & Cost of Fires

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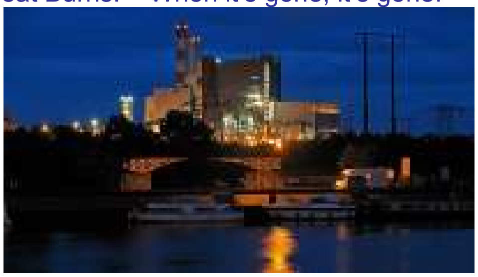
Peat Burns! – When it's gone, it's gone!



Old and new peat fired power stations of the Irish Electricity Supply Board at Shannonbridge on the River Shannon.

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Incidence & Cost of Fires

- Causes of Fires
- Environmental costs
- Socio-economic costs
- Vulnerability of Peak District National Park

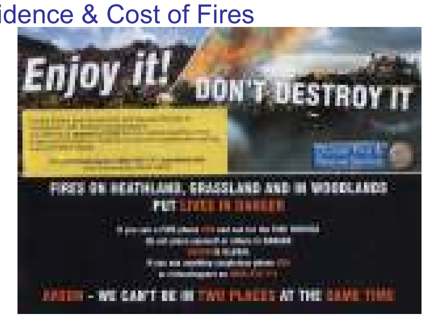
Climate Change and the Incidence of Moorland Wildfires

Incidence & Cost of Fires

- Causes of Fires
  - Three main causes of fire:
    men, women and children
  - Fires started accidentally or maliciously, or managed fires that get out of control
- Environmental costs
- Socio-economic costs
- Vulnerability of Peak District National Park

Climate Change and the Incidence of Moorland Wildfires

Incidence & Cost of Fires



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Incidence & Cost of Fires

- Causes of Fires
- Environmental costs
  - Threat to soil carbon store – equivalent to 3 years UK CO_2 emissions
  - Loss of habitat & wildlife
  - Peat erosion. Water supplies become contaminated with heavy metals & carbon
- Socio-economic costs
- Vulnerability of Peak District National Park

Climate Change and the Incidence of Moorland Wildfires

Incidence & Cost of Fires

- Causes of Fires
- Environmental costs
- Socio-economic costs
  - Difficult and costly to fight fires
  - Indirect costs
    Closure of transport links
    Ecosystem damage
    Loss of tourism income
- Vulnerability of Peak District National Park

Climate Change and the Incidence of Moorland Wildfires

Incidence & Cost of Fires

- Causes of Fires
- Environmental costs
- Socio-economic costs
- Vulnerability of Peak District National Park
  - most visited National Park
  - Climatically at southern limit of blanket bog
  - 354 wildfires in PDNP 1976-2004
  - Pioneered partnership approach
    Fire Operations Group (FOG)
    Fire Advisory Panel (FAP)

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Climate Change and the Incidence of Moorland Wildfires

What do we know about wildfire and climate change in PDNP?

- Data based on PDNP Rangers' fire log 1976-2008
- A slight increase in the frequency of extreme events has a disproportionate effect on likelihood of wildfire
- Hot/dry summers are a proxy for the results of climate change
- Summers 5° C warmer, last longer → more frequent hot, dry spells (climate drivers of wildfire)

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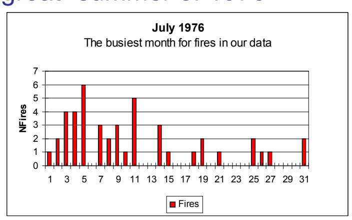
Climate Change and the Incidence of Moorland Wildfires

The "great" summer of 1976



- Albertson *& al*. (2009) fit a Probit model which explains the probability of fires in terms of prevailing climate conditions

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The Probit model

Pr(fire)	Coef.	Std. Err.	*z*
firewk	0·463	0·107	4·310
ppt	-0·080	0·023	-3·470
tmin	-0·082	0·016	-5·210
tmax	0·108	0·013	8·510
bh	0·606	0·158	3·850
fri	-0·300	0·142	-2·110
sat	0·250	0·104	2·420
sun	0·280	0·101	2·760
apr	0·592	0·116	5·100
may	0·442	0·103	4·300
p21	-0·101	0·037	-2·740
p56	-0·111	0·046	-2·430
ip7	0·237	0·092	2·570
t28	0·094	0·027	3·460
cons	-3·513	0·164	-21·480

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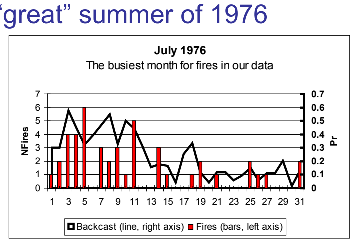
The "great" summer of 1976



- We expect to see more summers with such conditions
- How many fires does the model predict?

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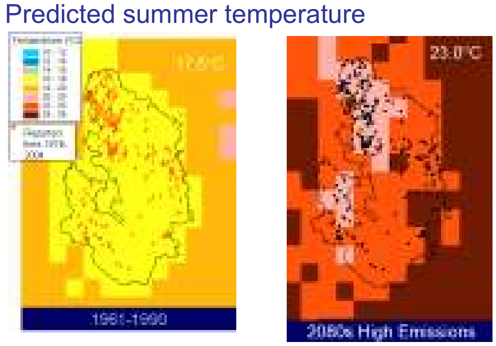
Predicted summer temperature



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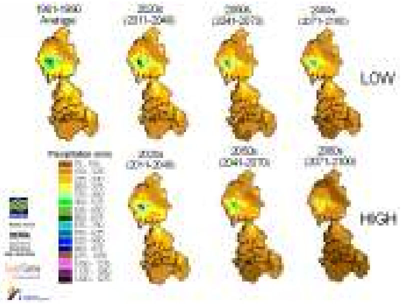
Predicted Average Summer Precipitation



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Climate Change and the Incidence of Moorland Wildfires

BETWIXT Climate Simulation

- BETWIXT provides simulated meteorological conditions for Buxton (in the High Peak)
- First order Markov-Chain simulations
- Seven sets of data
- Validation set: 1961 to 1990
- Low emissions scenario:
  - 2011 to 2040; 2041 to 2070; 2071 to 2100
- High emissions scenario:
  - 2011 to 2040; 2041 to 2070; 2071 to 2100

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Climate Change and the Incidence of Moorland Wildfires

BETWIXT Climate Simulation

- The data is stationary in each time-period!
- Structural breaks occur between time periods
- Naturally, the dates are representative only
  - These are climate simulations, not weather forecasts
- We analyse each 30-year period separately and interpret data on each year as one of 30 possible realisations for the mid-point of each set
  - 30 typical outcomes for 2025, 30 for 2055 *&c.*

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BETWIXT Climate Simulation

March/April/May

	Ppt		Tmin		Tmax	
	Mean	var	mean	var	mean	var
Actual 1979 to 2008	3·18	28·73	3·52	11·09	10·52	18·78
B_Va 1961 to 1990	2·77	26·96	3·1	11·8	9·59	15·38
B_lo 2011 to 2040	2·71	31·77	3·79	12·45	10·39	15·93
B_lo 2041 to 2070	2·8	36·1	4·07	12·43	10·47	15·94
B_lo 2071 to 2100	2·79	29·61	4·56	12·26	11·19	18·04
B_hi 2011 to 2040	3·01	36·07	3·96	12·96	10·31	16·51
B_hi 2041 to 2070	2·89	35·14	4·7	12·25	11·3	15·89
B_hi 2071 to 2100	2·79	38·21	6·22	11·67	12·86	17·21

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Climate Change and the Incidence of Moorland Wildfires

BETWIXT Climate Simulation

June/July/August

	Ppt		Tmin		Tmax	
	mean	var	mean	var	mean	var
Actual 1979 to 2008	2·99	32·81	10·16	6·41	17·96	12·56
B_Va 1961 to 1990	3·11	44·48	9·56	7·21	16·19	8·84
B_lo 2011 to 2040	2·47	36·22	10·66	9·38	17·63	10·42
B_lo 2041 to 2070	2·18	23·06	11·17	9·23	18·29	10·91
B_lo 2071 to 2100	1·63	18·32	11·88	9·89	19·46	12·17
B_hi 2011 to 2040	2·12	21·44	10·67	8·46	17·87	9·93
B_hi 2041 to 2070	1·63	20·01	12·05	10·88	19·47	11·95
B_hi 2071 to 2100	0·81	7·06	13·98	13·56	22·22	15·48

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Climate Change and the Incidence of Moorland Wildfires

BETWIXT Climate Simulation

June/July/August

	Ppt		Tmin		Tmax	
	mean	var	mean	var	mean	var
Actual 1979 to 2008	2·99	32·81	10·16	6·41	17·96	12·56
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Calibrating the Model

- The Probit model forecasts Pr(Wildfire), it does not forecast the number of wildfires
- Calibration, using the validation set – select p such that:
  the number of occurrences of Pr(Wildfire) > p = the number of wildfires
- In the years 1981 to 1990 (inclusive) there were 65 fire days.
- The value of p which gives 65 "fire-warnings" forecasts is p = 13·20%

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Climate Change and the Incidence of Moorland Wildfires

Forecasting

- Using BETWIXT and deterministic data, we create an explanatory variable set X
- The probability of a wildfire is found by

$$\Pr(\text{fire}) = \Phi\left(\frac{X_i\beta}{\sigma}\right) = \int_{-\infty}^{\left(\frac{X_i\beta}{\sigma}\right)} \frac{1}{\sqrt{2\pi}} e^{\left(\frac{-z^2}{2}\right)} dz$$

  where the ß vector is given on p.14 above
- The number of fires expected is the number of occurrences of Pr(fire) > 13·20%

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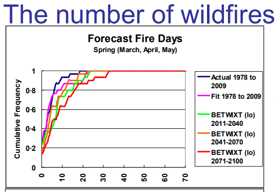
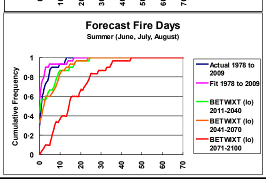
Climate Change and the Incidence of Moorland Wildfires

The number of wildfires by season: CDF's





- Each CDF based on 30 data points
- Summer becomes the more risky as that season experiences longer warmer dry spells
- By the end of the century, 25 fire days each summer may be typical

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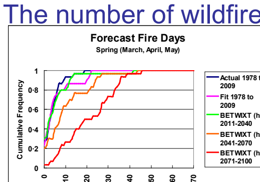
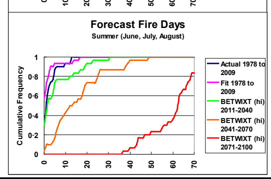
Climate Change and the Incidence of Moorland Wildfires

The number of wildfires by season: CDF's





- Under the "Hi Emissions" simulation, every summer is likely to have a similar profile to the "great" summer of 1976
- By the end of the century, we expect an average of five wildfires each week

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Climate Change and the Incidence of Moorland Wildfires

Summary and Conclusions

- Based on the Albertson *& al.* (2009) model, and using reasonable assumptions to simulate future climate we expect
  - Little change from the current distribution of wildfires for the next three decades – even under "hi" emissions scenario
  - Non-linearity in the model leads to an escalating risk by the mid-point of the century
  - By the end of the 21st century, fire-free summer days may be the exception

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