FIRES

Interdisciplinary Research on Ecosystem Services: Fire and Climate Change in UK Moorlands and Heaths

Seminar 2

The impact of wildfire on ecosystem services: relationships between wildfire, climate change and people

The University of Manchester
24th June 2008

Programme and Abstracts

Sponsored by:

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FIRES
Interdisciplinary Research on Ecosystem Services: Fire and Climate Change in UK Moorlands and Heaths

FIRES is a series of four seminars and workshops on the effects of moorland and heathland wildfires and managed fires on ecosystem services that will be held during 2008-2009. The series is funded by the ERSC/NERC Transdisciplinary Seminar Series on Ecosystem Services. The objective of this scheme is to support the development of trans-disciplinary research across social and natural sciences under the theme of sustaining future ecosystem services. It will bring together economists, social and environmental scientists, other experts and stakeholders to explore and develop ecosystems services approaches and help to build research capacity for future inter-disciplinary research in this field. The particular focus from ESRC/NERC is in advancing research and enhancing knowledge transfer with non academic users and/or the inclusion of international academics at events.

Context

Moorland and heathland ecosystems in the UK both sustain human use and are sustained by it. Fire plays a key but equivocal role, raising many controversies for management and policy making, especially under the anticipated threat of climate change.

The diverse environmental, social and cultural ecosystem services provided by moorlands and heathlands include carbon storage, biodiversity, water provision, flood protection, aesthetic/recreational value, and economic value from tourism, sporting enterprises and grazing.

Managed fire has traditionally played an important role in maintaining the landscape and biodiversity. For instance, rotational burning is used to maintain heather moors for grouse and grazing animals and contributes to floristic diversity.

In contrast, accidental or malicious wildfires increasingly threaten moorland and heathland ecosystem services and are likely to become more frequent and severe with climate change.

Managed fires and wildfires are linked. Managed fires can reduce wildfire risk by reducing fuel load and creating firebreaks, but, if poorly controlled, can result in wildfires themselves. Research on wildfires in UK moorlands and heathlands is in its infancy and lacks co-ordination. This seminar series seeks to contribute to effective management of wildfire risk by identifying policy implications and developing a joined-up research agenda for the UK.

Aims

The aims of the four workshops in the seminar series are:

1. to build capacity for inter-disciplinary research on fire and its impacts on ecosystem services of UK heaths and moorlands;

2. to establish a cross-cutting interdisciplinary research agenda on the relationships between ecosystem services, managed fire and wildfire in UK heaths and moorlands, especially implications of increased wildfire risk under climate change scenarios;

3. to incorporate the needs of policy makers, moorland managers and other stakeholders, facilitate knowledge transfer to policy makers and contribute to adaptive management response.

Specific Objectives

The objectives of the seminar series are:

- to facilitate dialogue between participants on three levels: socio-economic, environmental and physical scientists; researchers, international and UK academics and postgraduate students; and, especially, researchers, stakeholders and policy-makers;

- to identify the ecosystem services of UK heaths and moorlands, assess the role of managed fire in maintaining them and the costs and benefits of reductions in prescribed burning;

- to assess the threats to these ecosystem services posed by wildfire, including an anticipated increased threat from climate change;

- to evaluate the suitability for the UK of three broad categories of modelling tools designed to minimise damage to people and the ecosystem: forecasting the timing and severity of wildfire risk; modelling the behaviour of active fires; and spatially modelling their cause and distribution (including evaluating alternative conceptual and methodological approaches, identifying data needs and implications for policy);

- to identify alternative strategies for managing wildfire risk (now and in the future from climate change), discuss their relative costs and benefits for ecosystem services, and identify the political and institutional policy drivers;

- to disseminate findings and define an agenda for further cross-disciplinary research.

Funding

In addition to the core funding from the ERSC/NERC Transdisciplinary Seminar Series on Ecosystem Services, the FIRES Seminars are sponsored by Scottish Natural Heritage, the Game and Wildlife Conservation Trust, the University of Manchester School of Mathematics and the University of Manchester President’s Fund. Support in-kind is provided by the grant-holders’ and steering group’s institutions; the University of Manchester, University of Edinburgh, Moors for the Future Partnership, University of Leeds, Chief Fire Officers’ Association, and the Heather Trust.

FIRES Steering Group

Julia McMorrow (coordinator)	University of Manchester
Colin Legg	University of Edinburgh
Jonathan Aylen	University of Manchester
Jon Walker	Moors for the Future partnership
Klaus Hubacek	University of Leeds
Claire Quinn	University of Leeds
Simon Thorp	Heather Trust
Mark Jones	Chief Fire Officers’ Association
Gina Cavan	University of Manchester

Coordinated by: University of Manchester

FIRES Series Programme

Seminar One

The role of managed fire in ecosystem services of UK moorlands and heathlands. Edinburgh, 31 March – 1 April 2008

Over 60 delegates attended the first meeting of the FIRES series on 31 March in the magnificent surroundings of Playfair Library, Old College, University of Edinburgh. This was followed by a dinner and workshop in the Raeburn room for 35 invited participants, and a discussion seminar the next day in the Crewe Building.

The seminar reviewed how fire has been used historically, and the role of managed burning today. The ecosystem services provided by UK moorlands and heathlands were identified, including: biodiversity; carbon budget; water provision; rural livelihoods; landscape quality and recreational use. The focus for debate was the extent to which managed fires contribute to the maintenance of these ecosystem services or pose threats to them, especially with changes in climate.

Seminar Two

The impact of wildfire on ecosystem services: relationships between wildfire, climate change and people. Manchester, 24 June 2008

Seminar Three

Forecasting and modelling wildfire risk for UK moorlands and heaths. Manchester, 31 March – 1 April 2009

Seminar Four

Adaptive Management to Wildfire Risk: implications for ecosystem services of UK moorlands and heaths. Peak District National Park, May 2009

Further details of the Seminar Series are available from:

http://www.fires-seminars.org.uk

Seminar 2

The impact of wildfire on ecosystem services: relationships between wildfire, climate change and people

Manchester, 24th June 2008

Relationships between people, climate, the environment and fire are complex. The seminar will review the frequency, timing and distribution of wildfires in the UK. We will examine UKCIP climate change scenarios and their implications for wildfire hazard and risk, managed burns and resulting fire regime. Critical questions to be addressed include how climate change will affect: vegetation vulnerability to fire; visitor pressure and potential sources of ignition; feedbacks between climate, vegetation and fire; and the impacts on ecosystem services of moorlands and heathlands.

Feedback form

We would appreciate your views on the event. Please complete the feedback form in your information pack and hand it into the registration desk before you leave. The responses will help us to write the feedback section of the ERSC/NERC report.

There will be a raffle for completed feedback forms to be drawn after the seminar.

Programme - Tuesday 24th June

Invited Discussion Seminar

Hanson Room, Humanities Bridgeford Street Building,
University of Manchester

11:00 Coffee and registration

11:30 Welcome and introduction to the day.
Julia McMorrow (University of Manchester, FIRES seminar series coordinator)

Session 1: 'Where, when and why do wildfires occur in the UK?'

Chair: Simon Thorp (Heather Trust).
Rapporteur: James Rowson (University of Durham)

11.45 Keynote: Mark Jones (Essex County Fire and Rescue Service)

12.05 Responses: National Parks; Sean Prendergast (Peak District National Park, Ranger Service)

Heathlands; Andy Elliott (Dorset County Council)

Land management; Michael Bruce (Eurofire)

12.20 Round-table discussion

13:00 Poster introductions: opportunity for presenters to briefly introduce themselves and state their poster titles

13:10 Lunch and poster session
Poster presenters are requested to leave their posters up for the evening session

Session 2: 'How will climate change affect wildfire risk, hazard and fire regime?

Chair: Jonathan Aylen (University of Manchester).
Rapporteur: Vladimir Krivtsov (University of Edinburgh)

14:00 Keynote: 'Climate change scenarios for uplands'
Mark Gallani (Met Office), replacing Clare Goodess

14:20 Responses: 'How will climate change, access and wildfire interact?'
Sarah Haigh (Natural England)

'How will climate change and vegetation vulnerability interact? How will fire regimes change?'
Matt Davies (FireBeaters, University of Edinburgh)

14:40 Round-table discussion

15:20 Tea break

Session 3: Breakout groups: How will a changed wildfire regime affect ecosystem services? What are the research needs?

15:45	Soil:	Facilitator: Colin Legg (University of Edinburgh) Rapporteur: Stefan Doerr (Swansea University)
	Biodiversity:	Facilitator: Jon Walker (Moors for the Future Partnership) Rapporteur: Penny Anderson (Penny Anderson Associates Ltd)
	Access:	Facilitator: Klaus Hubacek (University of Leeds) Rapporteur: Simon Wright (National Trust, High Peak and Longshaw Estate).

16:25 **Plenary**

Chair: Julia McMorrow (University of Manchester)
Rapporteurs: Turkia Al-Moustafa (University of Salford) and Gina Cavan (University of Manchester)

Report back from breakout groups and plenary discussion on research needs.

Public Session

Cordingley Lecture Theatre, Humanities Bridgeford Street Building, University of Manchester

17:10 *Posters and wine reception, sponsored by the University of Manchester Humanities Bridgeford Street ground floor foyer.*

Poster presenters from the lunchtime session are requested to leave their posters up for this session.

18:00 Welcome, Julia McMorrow (University of Manchester, FIRES seminar series coordinator)

18:05 ***'Wildfires and Climate Change: An American perspective on Global Change.***

James Smalley, US National Fire Protection Association

18:50 Discussion.

Chair: Mark Jones (Deputy Chief Fire Officer for Essex.)
Rapporteur: Ethan Bigelow (Northwoods)

19:15 Close

20:00 *Informal dinner in Manchester Business School for invited participants staying overnight. There will be a steering group meeting over dinner.*

List of delegates

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1. Turkia AL-MOUSTAFA	University of Salford t.a.a.almoustafa@pgr.salford.ac.uk
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5. Iain BROWN	Macaulay Institute Aberdeen i.brown@macaulay.ac.uk
6. Michael BRUCE	Eurofire eurofire@gfmc.org
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10. Andrew DAVIS	Quantock Hills AONB Service and Forestry Commission andrew.davis@forestry.gsi.gov.uk
11. Stefan DOERR	School of the Environment and Society Swansea University s.doerr@swan.ac.uk
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33. Graham SULLIVAN	Scottish Natural Heritage Inverness graham.sullivan@snh.gov.uk
34. Simon THORP	The Heather Trust Dumfries simon.thorp@heathertrust.co.uk
35. Jon WALKER [represented by Andy JONES}	Moors for the Future Partnership jonathan.walker@peakdistrict.gov.uk andrew.jones@peakdistrict.gov.uk
36. Fred WORRALL	Dept of Earth Sciences University of Durham fred.worrall@durham.ac.uk
37. Ada WOSSINK	Economics, School of Social Sciences University of Manchester ada.wossink@manchester.ac.uk
38. Simon WRIGHT	National Trust High Peak and Longshaw Estate simon.wright@nationaltrust.org.uk

SESSION 1

'Where, when and why do wildfires occur in the UK?'

Keynote discussion paper

Mark Jones

**Essex County Fire and Rescue Service, Chair of English Wildfire Forum,
Deputy Chief Fire Officer for Essex,
Chief Fire Officers' Association spokesperson for wildfires**

Statistics

The recent wildfire history of the UK has been thankfully quite good – severe events in which people are killed are almost unheard of and, as taxing as they may be for agencies such as the ones I represent, our problems are incomparable to those faced in many other countries.

Traditionally, UK fire and rescue services have gathered reasonably good data on primary fires[1] but their knowledge on wildfires in general is scant and often not recorded in detail such as "area burned" or "type of vegetation involved". The soon to be introduced National Incident Recording System[2] (IRS) that has been designed and led by the Department for Communities and local government offers considerable hope and will address many of the data requirements for the future.

It is important to remember that even those fires that are recorded by FRS's are only those of which they are aware – many go unreported.

Where wildfires occur

It is tempting to simply respond that wildfires occur mainly in remote rural areas, and media reports would seem to bear this assumption out but this would be misleading. Large, highly damaging and long burning wildfires do occur in rural areas, but many smaller and more frequent ones occur in our most urban areas in the UK. Demographic spread is also relevant - as our society moves ever outwards from the centres of conurbations, increasingly, smaller wildfires are having an impact upon citizens in more built-up areas.

In 2006, England's six metropolitan Fire services (those serving distinctly urban areas) dealt with a total of over 28,000 grass and heathland fires. (All Scotland had 8,725 in comparison).

It must be recognised that, despite the statistics, wildfire is not a large part of the Fire and Rescue Service's (FRS's) planning and preparation. Even a precursory read of the national frameworks[3] that govern the work of FRS's in the UK will highlight that wildfire is a small aspect of FRS work, with more focus being given to those matters that tax us daily such as community safety and protecting lives and property. Essentially, whilst taxing occasionally, wildfire is not even as relevant as flooding which has much greater societal impacts.

In summary, whilst certain naturally ignited fires can occur, generally, wildfires occur wherever people come into contact with readily combustible fuels in the right

[1] "Primary" fires include all fires in buildings, vehicles and outdoor structures or any fire involving casualties, rescues, or fires attended by five or more appliances. "Secondary" fires are the majority of outdoor fires including grassland and refuse fires unless they involve casualties or rescues, property loss or five or more appliances attend.
[2] http://www.communities.gov.uk/fire/fireandresiliencestatisticsandre/firestatistics/newincidentrecording/
[3] http://www.communities.gov.uk/publications/fire/nationalframework200811

environmental conditions to cause fires. It is not, as one might have expected, merely a rural issue.

When wildfires occur

Simply overlaying the climate maps does not tell the whole story. Whilst there is a relatively linear relationship between fires (or fire propagation) and ambient temperature, it is vital to consider a range of factors. Wind speed and direction is highly relevant when considering the scale and potential impact that wildfires can have. School holiday dates, and the dryness of the winter and spring are also important factors.

The national report for fire statistics 2006, noted:

> "Outdoor fires exhibit the strongest seasonal pattern mainly due to the effect of the weather on grassland fires. There was an average of 729 grassland fires per day in July 2006, compared with just 35 fires per day in December 2006. Fires in dwellings showed a different seasonal variation, generally with higher numbers of fires per day occurring in the winter months."

Year	**Total no. of Primary "Outdoor" fires in UK (1000's)**
1996	385
1997	330
1998	278
1999	337
2000	348
2001	418
2002	401
2003	504
2004	336
2005	328
2006	337

In 2006, 27% of these were classified as grassland fires, (which included heathland and intentional straw and stubble burning). Roughly, this translates to over 90,000 fires.

2006 by Month	**"Grassland" Fires per Day**
Jan	246
Feb	50
Mar	128
Apr	193
May	171
Jun	296
Jul	994
Aug	409
Sep	156
Oct	76
Nov	72
Dec	23

Considering the "daily rate" gives further evidence to support the seasonal nature of the risk.

Why they occur or should it be "Why they are seemingly more problematic"?

As previously highlighted, weather is an important factor – it helps create the conditions in which wildfire can propagate and flourish. It does not normally; in itself cause fires to occur.

It should be noted that it is notoriously difficult to assess true causes of wildfires, although many are self-evident. The presence of people in an area may lead us to deduce causation, but does nothing to offer any theories as to what method was used and whether intent was apparent.

In the fire service, we tend not to get too scientific with outdoor fires but it is essential to recognise two a simple facts:

- Forest do not catch fire – fine fuels are the "item 1st ignited". Their readiness and capacity to burn, linked with their ability to sustain a fire that can become self-sustaining in fuel terms.

- Perpetrators will see these as victimless fires and harmless fun.

The EU have highlighted that increased access to land by people tends to lead to more fires (a fact that is supported by the nature of the access bans under the CRoW Act). Other factors worthy of consideration include: Significant changes in land management, longer growing seasons allowing more fuels to grow, and growing demand for amenity use of natural lands.

Societal tolerance is important to note. Just as people living in relatively safe areas can have their fear of crime greatly (and falsely) heightened by media reports, fear of wildfire in the UK can sometimes be irrational and shaped by dramatic media coverage of events elsewhere. As traditional urban dwellers move to the "natural interface", their acceptance of fire as a land management tool can be negligible. This too becomes apparent when Fire commanders from predominantly structural backgrounds (and with a strong instinct to attack and suppress fires) are confronted by wildfires which may be best left to burn.

Finally, the impacts of "remote" policy development can have unseen effects. For example, the workplace smoking bans that came into force a couple of years ago were well consulted upon. Those responses by FRS's of which I am aware confined themselves to their role as employers. In the summer of 2006, the roadsides of Eastern England's highways burned regularly due to carelessly discarded cigarettes. None of us foresaw that smokers would continue their habit somewhere – in the privacy of their own cars.

Respondent 1 (National Parks)

Sean Prendergast

Peak District National Park, Ranger Service

The question of when fires break out still unfortunately seems unanswered in the Discussion Paper. The answer is in fact well know; 5 o'clock, Sunday afternoon, just as everyone – including myself, has gone home and are sitting down for their tea!

Behind this quip is an element of truth. Wildfires are, as the paper points out, linked to visitor activity, which tends to peak on sunny Sunday or Bank Holiday Monday afternoons. This simple fact underlines much of the thinking behind the Fire Watch Patrols in the Peak District.

However it is too simplistic to state that increased access will mean more or even necessarily more damaging wildfires. The grass verges along roadsides, cited in the paper were ignited through ignorance, not access; similarly, the increase in access since the CRoW Act has not in itself increased the overall number of fires, nor, from the Peak District experience does it appear to have significantly altered their distribution. Fires still break out in popular locations due to a combination of ignorance or malice: a smoke break at a Trig point, a barbecue on a hill side or a malicious attempt to damage a Grouse moor. If anything the increase in people numbers may arguably even serve to reduce the length of time between outbreak and report.

There is an ongoing discussion in respect of the increasing fuel loads linked to reductions in management burns of Heather moorland already taking place between Natural England and Grouse Moor owners and it is probably best left for others to address this, however, the reason it is taking place at all is because many of these areas, particularly in National Parks, are afforded the highest protection at both National and European Level because of their unique environmental and ecological importance. The suggestion that they should be allowed to burn rather than be tackled is therefore a complete anathema. However, it does serve to highlight the very point that it seeks to make.

Fire Officers, particularly those from urban backgrounds, are often unaware of the special circumstances that can occur in rural wildfires. There is consequently a strong case for those agencies charged with the ecological and environmental protection of those areas; be they National Park Authorities, Natural England or even the local authority Countryside Service; together with the landowners, to work in partnership with the Fire Services, in combating wildfires. They each bring specialists skills and information and together can provide practical tools such as Fire Plans, made available to all parties and containing key information and contact details. In addition, this partnership approach can result in specialist equipment such as all terrain vehicles, which although primarily used for land management, being easily and quickly adapted at time of need to fire fighting. As has already been proved in a number of Areas, solid partnerships between land owners, statutory agencies and Fire and Rescue Services can provide practical and tangible benefits through reduction, duration and impact of wildfires in the United Kingdom.

Respondent 2 (Heathlands):

Andy Elliot

Senior Geographical Information Systems Developer, Dorset County Council (Retained Station Commander, Dorset Fire and Rescue Service).

Statistics

Monitoring and recording systems established in Dorset have highlighted how poor the recording systems of Fire and Rescue Services are for wildfires. Where estimates have been made they are often wildly inaccurate. In fact according to Dorset Fire and Rescue Service, during one year at the end of the 1990's an area nearly equivalent to the size of Belgium was destroyed by heath fires! We look forward to the improvements offered by the National Incident Recording System.

Where?

As Mark states in his paper, wildfires are not solely a rural problem. In general terms it is true to say that in Dorset the vast majority of our heathland fires occur within the conurbation of Poole and Bournemouth. These are often small and quickly dealt with, but a few each year get away and can run into protracted incidents calling on 20 or more pumps. Our large open heathlands burn much less frequently but due to their relatively remote location can often be protracted and costly in manpower and pumps.

When?

Once again the work done by the Urban Heaths Partnership (UHP) in Dorset would support Mark's statement "Simply overlaying the climate maps does not tell the whole story". Our experience is that the weather has an affect, but in the urban area it would appear that school holidays and the end of the school day would be the most important factors. Another important element is criminal activity. One active arsonist can cause a very large number of unwanted heath fires within a very small space of time. Liaison with the Police Force is essential to detect and deal with this problem. Operation Heathland is a joint operation between Dorset Police, Dorset Fire and Rescue Service and the Urban Heaths Partnership that runs every summer. All partners are involved in collecting data which is mapped to help identify patterns of criminal activity.

Why?

The UHP investigate all fires in an attempt to determine the cause. This is never simple and often inconclusive, but they have been successful in one area. That is how the fire is recorded by the Police and the Fire and Rescue Service. In the past these fires were recorded as 'accidental', this trend has now ceased and the majority of fires are recorded as 'deliberate'. This means that the fires are recorded as crimes, which, in turn, generates a desire to reduce the number of fires by all agencies. None of the fires investigated to date have been recorded as naturally occurring, they all seem to have a cause and these causes invariably lead back to a person. Some are genuinely accidental but the vast majority would appear to be deliberate.

There is a clear relationship between the close proximity of people to the fragmented heathland in Dorset and the number of unwanted fires. As more properties are being built ever closer to the remaining heathland areas in the UK it is probable that we will see an increase in unwanted wildfire in the UK.

On a positive note the Dorset trend is dropping due to close partnership working and a growing understanding amongst young people of the importance of our heathlands.

Respondent 3 (Land management)

Michael Bruce

Eurofire Project

Summary of keynote paper:

Urban and rural issue that is low priority as is not perceived to effect life/property FRS priorities. People cause fires, children and access issues. The fire environment, type of fuels (fine fuels) and seasons are relevant to ignition and development of wildfires. The fear of wildfires may be exaggerated due to media coverage.

Land Manager's perspective:

- The property that the land manager is involved in is what is most important to him/her and that local community.
- Is there sufficiently robust information about where, when and why *(and how large)* damaging wildfires occur, to drive policy?
- Do Fire and Rescue Services recognise rural land and the eco-system services that derive from the land as an asset i.e. property that should be protected?
- Do the government(s) land management policies and priorities have an influence on the prioritisation of Fire and Rescue Service resources?
- Managing land carries responsibilities for the stewardship of that land and a duty of care to the people who are on the land, whether employees or members of the public. Does the lack of robust information on fire risks on both a temporal and spatial basis, driven by the condition of fuels and the weather; hinder appropriate management decisions and the provision of warnings?
- Could fire hazard and risk assessment, with the implementation of control measures on an estate by estate basis, drive prevention work? When and what prevention work should be carried out?
- Ignitions happen from a wide variety of causes that are unlikely to stop, should more emphasis be placed on hazard reduction and mitigation e.g. fuel reduction burning and the creation of firebreaks?
- The Met Office Fire Severity Index (MOFSI), which is used to control access in exceptional weather conditions, is derived from the Canadian Fire Weather Index. MOFSI attempts to identify exceptional fire danger periods both in time and space *(when and where)*. However to improve it as a general fire management tool for the UK should further research and calibration work be carried out on it? For example should the Fine Fuel Moisture Code be used to drive the fire danger index rather than the Fire Weather Index? Who should pay for it?

SESSION 2

How will climate change affect wildfire risk, hazard and fire regime?

Climate Change Scenarios for uplands

Keynote discussion paper

Dr Clare Goodess

Senior Research Associate and Research Manager, Climatic Research Unit, University of East Anglia

Unfortunately, Clare is unable to attend. Mark Gallani, Met Office has kindly offered to present on this topic

One of the acknowledged impacts of the hot dry summer of 1995 was on the number of secondary fires (which include grass and heathland fires). Using data for the period 1984-1995, Palutikof (1997) found a clear positive relationship between temperature and the number of secondary fires in England and Wales, together with a clear negative relationship for rainfall. According to a more recent assessment by the Fire Brigades Union (FBU), the annual number of heathland and grassland fires in the UK has risen from an average of 37,371 in 1986-1993 to 60,332 in 1994-2005 (Guardian, 2007). In 2003, which saw the highest ever UK maximum temperature of 38.5°C on 10 August at Faversham, Kent, 152,700 grassland fires were recorded – a near record. Records were also broken in 2006 – July 2006 was the warmest month in the Central England Temperature record since observations began in 1877 (Jenkins *et al*., 2007). In August 2006, the FBU warned of the impacts of climate change as Ilkey Moor and Arthur's Seat were extensively damaged by fire (FBU, 2006).

Thus events of recent years have served to raise awareness of the potential negative impacts of climate change on wildfires in the UK (CLG, 2006). To date, however, European research has tended to focus on the Mediterranean – where modelling studies indicate both a longer fire season and increased risk (MICE, 2005; Alcamo *et al*., 2007).

In order to undertake quantitative studies of the impacts of climate change on UK wildfire occurrence, appropriate climate change scenarios are required. The current national climate change scenarios (UKCIP02) provide information for 50 km grid boxes across the UK (Hulme *et al.,* 2002) but will be replaced by the UKCIP08 projections in November 2008. These new scenarios will provide enhanced treatment of the uncertainties through a probabilistic approach and will also provide information at higher temporal and spatial resolutions. This will be very valuable information for risk assessment and decision making.

In the meantime, some of the key results from UKCIP02 are summarised here:
- UK climate will become warmer
- High summer temperatures will become more frequent and very cold winters become increasingly rare
- Winters will become wetter and summers may become drier everywhere.

This key message of 'hotter, drier summers' is clearly of concern from the perspective of wildfire occurrence. However, understanding fire risk requires more detailed consideration of hazard, vulnerability and exposure. Some of the outstanding research issues and challenges with respect to climate are summarised below. It is important to recognise, however, that climate change is only one of many factors that need to be considered.

Direct and indirect effects of climate change

- The occurrence of hotter and drier conditions is expected to have a direct effect on wildfire occurrence
- But also need to consider 'indirect' effects:
    - On ecosystems (affecting type and volume of combustible material, and also land cover/use)
    - On human behaviour (e.g., more visitors during 'better' weather)
    - On fire fighting (e.g., shortage of water and hot working conditions)

Seasonal changes

- Although wildfires currently peak during the hotter months, climate changes throughout the year need to be considered:
    - Winter rainfall – affects water availability, soil conditions, and vegetation conditions in summer, e.g., the projected increase in winter rainfall could help to prevent drying out of peat bogs
- Will climate change increase the length of the season of wildfire risk in the UK?

Temperature and rainfall are not the only relevant factors

- Wind may be a factor in the spread of, and ability to fight, wildfires – but is not well simulated by climate models and there is great uncertainty in wind projections
- Soil moisture conditions are likely to be important (and are also thought to play an important climatic role, e.g., in enhancing summer drying and heating)

Need to consider extremes and persistence of events as well as average changes

- So need information at higher spatial and temporal resolutions – which can be a challenge for climate models and downscaling tools
- Need to consider the persistence of events as well as their magnitude - but in general, climate models and downscaling tools tend to underestimate persistence (e.g., both the length of dry spells, and the length of warm/settled spells of weather associated with blocking in the North Atlantic, are underestimated)
- Changes in variability also need to be considered, both within seasons, and from year-to-year [can we expect more sequences like 2006/2007? (the hot dry summer of 2006 was followed by the wettest May to July period in England and Wales since the monthly record began in 1766)]

Uncertainty and scale

- In general, the uncertainty in climate projections tends to increase with spatial and temporal scale (Christensen *et al*., 2007)
- Local topographic effects are not fully incorporated in climate projections
- Summer rainfall projections tend to be more uncertain than winter projections (because summer rainfall is more associated with smaller-scale convective events, and winter rainfall with larger-scale frontal rainfall)
- While probabilistic projections such as UKCIP08 will provide a better representation of the uncertainties than 'deterministic' scenarios such as UKCIP02, and are consistent with the move towards risk-based decision making, they nonetheless raise several communication challenges (SKCC, 2007a,b).

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For access to the IPCC reports including Summaries for Policy Makers: http://www.ipcc.ch/

Respondent 1:

Sarah Haigh

Natural England

How will climate change, access and wildfire interact?

Natural England's position: Strategic Outcomes, and associated relevant objectives

1. A healthy natural environment → ecosystems and habitats **resilient to climate change**.
2. People are inspired to value and conserve the natural environment → **people** have places to **access and enjoy** the natural environment.
3. Sustainable use of the natural environment → land managed in a way that delivers **environmental services** alongside other benefits.
4. A secure environmental future → the natural environment is **resilient in the face of climate change**.

Direct and indirect effects of climate change

- As climates changes, a range of species are moving northwards and upwards.
- Climate modelling suggests that conditions may no longer be suitable for red grouse in English uplands by the late 21st century.
- If habitat for grouse declines, than the motive for prescribed burning will also decline, potentially leading to increased fuel load.
- Encouraging people to get into the natural environment will increase the risk of fires.
- However, more people enjoying and appreciating upland areas means there are more people with a vested interest and commitment to protect the environment, and report any fires to the relevant authorities.
- Wider range of people enjoying and understanding the natural environment = wider engagement of the population, raising profile on the political agenda, and possibly an increase to funding.

Seasonal change

- Phenology changes - spring events are happening earlier and autumn events are happening later, and this trend is projected to continue.
- Season for ground nesting birds getting earlier, leading to overlap with prescribed burning season.
- More extreme weather could lead to increased risk of losing control of prescribed burning.
- Longer season when wildfire is a greater risk.
- Prescribed burning practices will need to be adjusted accordingly.

Countryside and Rights of Way (CRoW) Act 2000

- Under the CRoW Act, fire prevention restrictions on open access land can be activated by the Met Office's Fire Severity Index (FSI) when exceptional weather conditions occur.
- How should exceptional be defined in the future to reflect climate change? Does exceptional become more frequent, or does the point of exceptionality move?
- Committed programme of monitoring and development of the FSI.

- Met data is being collected on NNRs in England and Wales to feed into Centre for Ecology and Hydrology's monitoring of climate change
- Selected NNRs in England and Wales are also monitoring soil moisture, primarily to evaluate the performance of FSI.
- NE and CCW backing Edinburgh University to look at point of combustion and potential for smouldering in peat, to develop a model to determine the point of exceptionality.

Natural England's focus on climate change

- Key objective is to work towards a natural environment that is resilient to climate change and contributes to tackling the causes of climate change.
- Peatland is the most important, but also most vulnerable, UK store of carbon.
- It is vital that we engage people and raise awareness of the importance of peat as a carbon store. Increased awareness = increased ownership.
- Also vital that we raise the profile of land managers' role in protecting peat as a carbon store.
- Working to develop a methodology to measure and verify the carbon savings delivered from peat restoration, which could be used to generate carbon credits for landowners.
- However, carbon stored in peat could be lost through wildfire.
- Another project is looking at likely impacts of climate change on four discreet landscapes (Joint Character Areas), to define key environmental assets, assess what direct and indirect impacts of climate change are likely to mean, and formulate response strategies.
- For example, Shropshire Hills is a relatively fragmented landscape with some large patches of disconnected habitat – how can we connect those areas so that species can more easily move in response to climate change?
- When UKCIP08 comes out, Natural England plans to try it out on an example area, such as Moor House NNR, to project future likely scenarios on a site basis.

Respondent 2:

G. Matt Davies

FireBeaters, University of Edinburgh

How will climate change and vegetation vulnerability interact? How will fire regimes change?

A number of key themes can be identified in current climate scenarios that have significant direct implications for fire hazard in heathland areas. Fire hazard is different from fire risk as it describes the flammability and potential for a fire to develop rather than the actual chance of a fire occurring. There are two principal areas associated with fire hazard that climate change could effect:

- **Fuel moisture content** (FMC) – the water content of dead and live vegetation that directly affects its ability to catch fire, rate of combustion and the intensity of the fire
- **Fuel structure** – the amount of flammable material and its organisation in three dimensional space that affects rates of heat transfer and oxygen flow

Below are identified some of the possible effects of climate change on each of these aspects of fire hazard with regards to heather (*Calluna vulgaris*), grass (*Molinia caerulea* being of principal concern) and peat. Following this the effects possible feed-backs in the system are briefly considered as well as what these changes mean for researchers and practitioners.

Fuel Moisture

1 Heather Fuel Moisture		
Climatic change	**Specific impact**	**Effect**
Reduction in cold winters	Frequency and duration of cold and frozen ground reduced	Reduced physiological drought and increased spring live FMC
		Water not "frozen in" to dead fuel leading to reduced dead FMC
	Reduced snow cover	Increased winter damage to leaf cuticles and reduced spring live FMC
Wetter winters	Frequent rainfall	Increased live and dead FMC
	Water-logged ground	Decreased root activity and reduced live FMC
	Increased cloud cover	Reduced fuel temperatures and increased dead FMC
		Reduced evapotranspiration and increased live FMC
Dry summers	Increased drought	Reduced dead FMC
		Reduced live FMC in sandy heaths but limited effect on peatlands
Warmer summers	Improved conditions for growth	Earlier onset of plant growth and early recovery of live FMC
		Increased evapotranspiration and reduced late season live FMC
		Improved drying conditions and reduced dead FMC

2 Grass Fuel Moisture		
Climatic change	**Specific impact**	**Effect**
Dry summers	Increased drought	Early on-set of grass “curing” and reduced FMC
		Reduced dead FMC
Warmer summers	Improved conditions for growth	Early on-set of growth and green-up
Wetter winters	Frequent rainfall	Increased dead FMC

Uncertainty in the response of wind is extremely important as wind plays a crucial role in allowing fuel to dry by removing the “boundary layer” of moist air that develops over fuel beds.

Fuel Structure

3 Heather Fuel Structure		
Climatic change	**Specific impact**	**Effect**
Drier summers	Increased drought	Reduced productivity and rates of fuel build-up
	Extreme drought conditions	Die-back and increased proportions of flammable dead fuel
Warmer summers	Improved conditions for growth	Increased rates of fuel build-up
	More rapid transition to mature/degenerate stage	Reduced bulk density and increased flammability

4 Grass Fuel Structure		
Climatic change	**Specific impact**	**Effect**
Warmer summers	Improved conditions for growth	Increased productivity and fuel load
Drier summers	Increased drought	Reduced productivity and fuel build-up
	Extreme drought conditions	Early on-set of curing and greater proportions of dead fuel

Uncertainty in wind forecasts is again of concern as wind plays an important role, particularly in shaping heather canopies and “shaking out” dead material thus reducing their flammability

The tables above show possible effects on vegetation but the situation is complicated by the effect a changed climate will have on species competitive interactions. Could a warmer climate encourage a transition to grassland for instance?

Effects on peat flammability

- Increasing precipitation in winter will increase peat moisture contents and help to reduce the risk of severe peat fires
- Reduced frozen ground conditions in spring may increase the potential for superficial damage from spring prescribed burning
- Warmer temperatures in spring and summer combined with reduced precipitation in summer will increase aerobic decomposition
- Increased exceptional drought conditions may allow for and increasing incidence of summer peat fires

- With regards to the overall moisture status of peat where does the balance lie between increased drying in summer and increased re-wetting in summer?
- Could generally more severe fires that burn away layers of moss, scorch the peat surface reduce ability for water uptake, increase fire hazard and the potential for erosion?

Possible Feed-back Mechanisms and Implications

- Changing possibilities for land use, species composition and rates of grazing will alter fuel structure.
- Shifts in natural and anthropogenic tree lines and woodland incursion will alter vegetation and impact on peat moisture dynamics.
- Exceptional/severe fires may initiate long-term vegetation change with unknown results for fire hazard.
- Changes and uncertainty in weather conditions may restrict conditions for prescribed burning leading to increased number of escaped management fires.
- Reduction in spring frost and frozen ground may reduce incidence of "catch-out" conditions and reduced number of spring wildfires.

Climatic changes will initiate a range of impacts on fuel structure and moisture content that can both increase and decrease fire hazard. Currently it is difficult to know where the balance lies and researchers need to focus on integrating knowledge of plant growth rates and physiology as well as species interactions and response to extreme events to try and develop some understanding of how fire regimes will change. We need to move beyond simplistic assumptions that hot summers = high fire hazard, wet winters = low fire hazard and deal with the real complexities of the situation. Managers need to be aware of this increasing uncertainty and not rely on traditional rules of thumb. Safe prescribed burning requires good knowledge of fire behaviour and vegetation ecology and the use of developing fire forecasting tools.

Session 3

Breakout groups: How will a changed wildfire regime affect ecosystem services? What are the research needs?

1. Soil

2. Biodiversity

3. Access

Plenary

Poster Abstracts

Development of a knowledge information system within the 'Fire Paradox' project

Colin Legg, Boris Pezzatti and Vladimir Krivtsov
The University of Edinburgh

Wild fires are a serious problem affecting many terrestrial ecosystems and causing substantial economic damage. Prescribed burning, however, is an important tool of environmental management and under certain circumstances has beneficial effect on ecosystem services. Fire behaviour depends (in part) on the availability and characteristics of the fuel, which in natural landscapes is predominantly represented by plant litter and live vegetation. Therefore, a comprehensive collation of the information relevant to plant/litter fuel complexes, fire occurrences, and the concurrent ambient condition is needed to enhance the understanding of this phenomenon (and therefore our ability to design effective preventive and mitigating measures).

This poster will report on the development of a pilot object oriented database of fuel complexes (Fig.1), carried out within the 'Fire Paradox' project (http://www.fireparadox.org/project_summary.php). We consider the fundamental unit of the database to be the 'Fuel Particle' with properties of size, moisture content, heat of combustion, etc. Fuel particles can be combined at increasing spatial scales to create a fuel complex. The 'biological' approach in Figure 1 has a strong hierarchical complexity in that branches are grouped into plants which are grouped into populations and thus to communities or ecosystems. The cube model of a fuel complex is, however the least hierarchical with landscapes comprising large collections of more-or-less independent fuel descriptions at the cube level. Other intermediate approaches are possible that permit aggregation of the lowest units using statistical functions of heterogeneity and texture of individual strata within the vegetation. It is envisaged that, ultimately, the database described will comprise an important part of a free-access internet-based knowledge information system (Fig. 2).

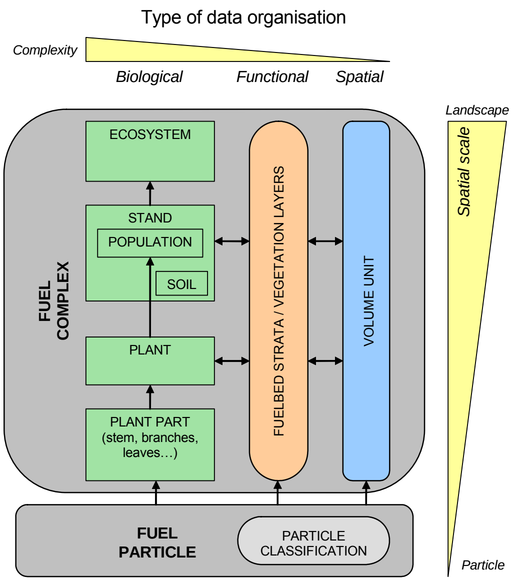

Figure 1. Conceptual structure of fuel data with examples of some of the different ways in which fuel complexes may be represented.

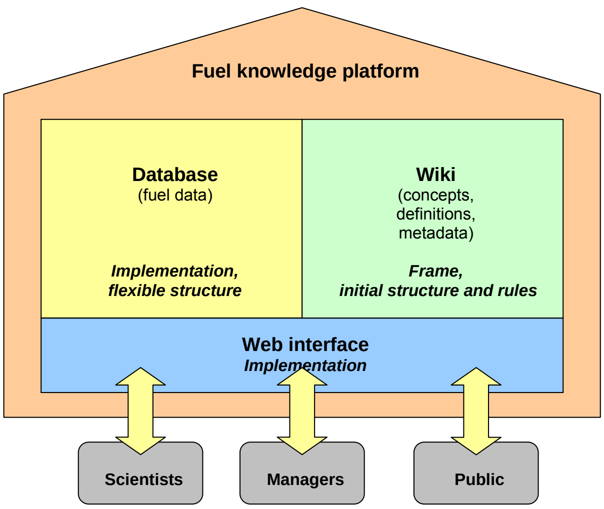

Figure 2. Overall structure of the application.

The implementation of the system will start with the database application as outlined below. The specification for a wiki will be developed shortly. This will require consideration of the scope, structure and constraints that will be imposed on contributors.

Measuring carbon fluxes and soil pore water properties on a wildfire site

James Rowson
University of Durham

Wildfire events are predicted to increase in frequency and intensity due to climate change. Upland peat is especially sensitive to changes in the carbon balance with the effect of turning these historic carbon sinks into sources of carbon by removing vegetation, increasing rainfall runoff, reducing infiltration capacity and increasing depths to water table. This study measures net and respiration CO_2 fluxes, water table depths and soil pore water chemistry for a year after a wildfire. Maximum respiration fluxes were 0.27 $gCO_2m^{-2}h^{-1}$ whilst maximum primary productivity values were -0.20 $gCO_2m^{-2}h^{-1}$. Average respiration values were 0.06 $gCO_2m^{-2}h^{-1}$ whilst average primary productivity values were 0.007$gCO_2m^{-2}h^{-1}$. Water table depths ranged from greater than 80 cm in depth to water table depths at the surface, with the average water table depth being 26.9 cm. The amount of CO_2 produced, normalised for soil temperature and water table depth, shows that the wildfire site has low soil microbe CO_2 productivity less than a control site in the area. Soil pore water chemistry pH appears to be stable over the year with an average pH over the year of 4.26 with a slight increase in average pH in October to 4.86. The E4/E6 ratio over the year shows the site to be releasing humified carbon and that there it little fresh litter input to the site when compared to the control site. DOC values in the soil pore water ranged from over 60ppm to a minimum of 20.2 ppm with an average value of 50.1ppm. The control site had maximum values of over 60ppm with a minimum value of 3.77ppm with and average value of 41.3ppm showing the wildfire site to be a greater source of DOC.

Developing Wildfire Management through Fire Groups in Northern England

Ethan Bigelow
Rural Development Initiatives, Morpeth

This poster will introduce the Fire Group model which has been successfully established in Northumberland and is now being rolled out across Cumbria. This model focuses on delivering wildfire management through effective partnership between key public sector bodies and land managers, sharing knowledge, skills and resources. Key activities of the group:

- Joint training courses (Lantra Awards approved)
- Standardised Fire Plans
- Live fire exercises
- Development of Standard Operating Procedures
- Public awareness activities

This model has proved very successful in Northumberland and a number of key factors have been identified which contribute this success. These include an independent body to facilitate the group and put together a funding package, strong support from the Fire and Rescue service, equality amongst partners, involvement of land managers from the very early stages and multiple opportunities for partners to get together.

Kate Hutchinson and Ethan Bigelow from Rural Development Initiatives will be present to answer questions.

The estimation of fuel moisture content (FMC) based on the spectral reflectance for fire risk assessments: Case study on Burbage Moor, UK

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Key words: fire risks, Burbage Moor, spectral reflectance, fuel moisture content (FMC), moorlands

Uncontrolled moorland fires have a negative effect on plant and animal biodiversity, soil stability and nutrient dynamics. A major problem that faces those charged with managing the risk of uncontrolled fires is actually mapping fire risk. One promising tool for doing this is hyperspectral remote sensing. This technology is fast and non destructive and allows for the observation and measurements of large areas on a regular basis. This study aims to investigate whether fuel moisture content (FMC), derived from the spectral reflectance of vegetation, can be used to predict moorland fire risk. Consequently, fieldwork has been conducted on a fortnightly basis to obtain ground-based data on vegetation spectral reflectance, FMC, leaf area index, soil moisture, canopy height and vegetation composition at six plots representing different vegetation stands on Burbage Moor, UK. Vegetation spectral reflectance has been obtained by using a spectroradiometer. Initial results indicate that there is a correlation between FMC, calculated using traditional methods, and reflectance measure at certain key wavelengths.

Therefore, it appears that fire risk could be forecasted based on spectral reflectance. The implication of this is that remote sensing could have a role in timely mapping fire risk for large areas of moorland.

Wildfire risk and climate change in the Peak District National Park

Julia McMorrow [1], Sarah Lindley 1, Jonathan Aylen [1], Kevin Albertson [2], Gina Cavan [1]

[1] The University of Manchester

[2] Manchester Metropolitan University

Wildfires are uncontrolled vegetation fires occurring accidentally or due to arson. Although they rarely cause loss of human life in the UK, they are a significant economic and environmental problem in moorlands. Vegetation fires in remote areas are costly to fight and detract fire-fighting resources from urban areas. They threaten peatland ecosystem services, for instance by ignition of carbon store in combustion and by initiating peat erosion. The latter requires costly restoration of the fires scars.

Wildfires are not a new phenomenon, but results from the recent Climate Change and the Visitor Economy (CCVE) project suggest that climate change is likely to increase the probability of wildfire outbreak by lowering environmental capacity (vulnerability of vegetation) and increasing visitor numbers (risk of ignition). Fires like the one on Easter Bank Holiday weekend 2003, which burned 844 ha of peat moorland on Bleaklow in the Peak District National Park (PDNP), are likely to become more common. The poster reports on work on wildfires in the PDNP conducted for CCVE and subsequently for Moors for the Future and the PDNP Fire Operations Group. The Park could be regarded as a good analogue; it is Britain's most visited National Park and marginal climatically for many moorland species – conditions which would be likely to affect to currently wetter, more northerly and westerly moorlands under climate change scenarios.

Temporal modelling predicted *when* wildfire risk is likely to be highest using the PDNP rangers' 28-year fire log of over 350 wildfires and daily weather records with non-linear probit modelling. . Results suggest that more frequent hot, dry spells during future UK summers will create extreme conditions with a disproportionately large effect on the probability of wildfire. The model assessed the chance of fires at different times of the year, days of the week and under various preceding weather conditions. The risk of an outbreak increases with temperature, reflecting the interplay between biophysical hazard and human use. The probability of fire on a Spring Bank Holiday Monday rose from 8% at the current average temperature of 15°C, to 26% at 25°C, and 50% at 30°C. It complements Met Office Fire Severity index by forecasting risk – the combined effect of weather on biophysical hazard with indirect effects on increased visitor numbers.

Spatial modelling used multi-criteria evaluation and stakeholder input to identify *where* wildfire risk has historically been highest. Habitat type was used as a proxy for vulnerability to ignition (hazard), and human access factors for availability of ignition sources (risk). Frequency of wildfires increased with proximity to popular footpaths and on Access Land, with implications for increased fire risk since the extension of access land under CroW. Bare peat and eroding moor were the most vulnerable habitat types, so restoration to favourable condition should reduce fire risk, provided that fuel load is managed. The map has helped to position fire watches and new fire ponds.

The combination of climate modelling, temporal and spatial analysis is a powerful tool for predicting and managing future fire risk. There is much potential to produce a decision-making tool able to identify areas and times of highest risk and to model the potential impact of fire risk management strategies under climate change scenarios.