Seminar 3
Forecasting and Modelling Wildfire Risk for UK Moorlands and Heathlands

The University of Manchester
31st March – 1st April 2009

Programme and Abstracts

Sponsored by:
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, and the Manchester Institute for Mathematical Science (MIMS). 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

An invited audience of 38 attended the one-day FIRES2 seminar in Manchester. Over half of the attendees were practitioners. Five participants were supported under the series’ early career scheme, acting as session rapporteurs and presenting posters.

Mark Jones, the Chief Fire Officer Association’s spokesperson on wildfire, gave the first keynote on the frequency, timing and distribution of wildfires in the UK. A lively discussion followed, assisted by contrasting views from respondents. In session two, Mark Gallani of the Met Office, outlined UKCIP climate change scenarios for uplands. The discussion focussed on two related implications – fire risk and hazard. Breakout groups discussed the impact of these hypothesised changes in fire regime on ecosystem services of moorlands and heathlands, and the research needs arising from this.

The day closed with a reception and an excellent public lecture from Jim Smalley of the Wildland Fire Protection section of the National Fire Protection Association (NFPA), which set the day’s discussions in context by providing a North American perspective on climate change, wildfire and the implications for management.
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, 13-14 May 2009

Further details of the Seminar Series are available from:

  http://www.fires-seminars.org.uk
Seminar 3

Forecasting and Modelling Wildfire Risk for UK Moorlands and Heathlands
Manchester, 31st March – 1st April 2009

This seminar will focus on three modelling tools used to minimise damage to ecosystems; forecasting timing and severity of wildfire hazard and risk; modelling the behaviour of active fires; and geospatial models to show how risk varies from place to place and investigate causes. Alternative conceptual and methodological approaches will be discussed. We will explore how mathematical and physical models of fire behaviour fit UK peatland fires, whether they could be improved with geospatial data and how they could improve fire-fighting strategies.

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.
Day 1 Programme - Tuesday 31st March 2009

Alan Turing Building, School of Mathematics, University of Manchester

11:00 Coffee and registration – Maths, Alan Turing Building

11:20 Welcome and introduction to the day,

11:30 Session 1: ‘Wildfire Risk Assessment’
   Keynote: Dr Paolo Fiorucci, CIMA Research Foundation, Savona, Italy
   ‘Wildfire Risk Assessment and Management WRAM’

13:25 Poster introductions: Opportunity for presenters to briefly introduce themselves and state their poster title

13:30 Lunch and poster session

14.30 Session 2: ‘Spatial aspects of wildfire’
   Keynote: Professor Cristina Vega-García, Associate Professor, Department of Agriculture and Forestry Engineering, University of Lleida
   Discussant: Professor Mark Danson, University of Salford

16:30 Coffee – Schuster Building

17:00 Session 3: ‘Fire behaviour modelling’, Two International Keynote Lectures: Rutherford Lecture Theatre, Schuster Building
   Professor Carlos Fernandez-Pello, University of California at Berkeley, “Wildland Fire Spotting”
   Professor Domingos Xavier Viegas, University of Coimbra, "Extreme Fire Behaviour and Fire Safety"

19:00 Depart / buffet in Alan Turing Building for delegates
Day 2 Programme – Wednesday 1st April

‘Science into Practice’

Discussion Seminar - By invitation

The aim of this second day is to focus on specific themes where fire science can help and inform fire prevention, fire fighting and restoration. The idea is to identify the issues and priorities facing fire services, to use the expertise of the group to identify existing knowledge that might be put into practice and inform theory and to spot gaps in knowledge where further research is needed.

An informal panel has been convened for each session to provoke discussion through short, introductory comments.

9:00 Coffee

9:15 Introduction to the day

9.30 Session 1: Science for firefighting strategies

   Professor John Dold, University of Manchester

   Albert Simeoni, University of Corsica

10.45 Coffee

11.00 Session 2: Prediction systems:

   Jonathan Aylen, University of Manchester

12.30 Lunch

13.30 Session 3: Data needs:

   Andy Newman, West Yorkshire Fire and Rescue Service

   Rob Gazzard, Forestry Commission, England

15.00 Summary

15.15 Depart

[15.30 Steering group meeting]
[17.00 Close]
## List of delegates

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DAY 1: SESSION 1

‘Wildfire Risk Assessment and Management’

Keynote discussion paper

Dr Paolo Fiorucci

CIMA Research Foundation, Savona, Italy
DAY 1: SESSION 2

Spatial aspects of wildfire

Keynote discussion paper

Professor Cristina Vega-García
Associate Professor, Department of Agriculture and Forestry Engineering,
University of Lleida
Modeling Wildland Fire Propagation and Spotting
by
Carlos Fernandez-Pello
Department of Mechanical Engineering, University of California Berkeley,
Berkeley, CA 95720-1740, USA

Abstract

Firebrand spotting is a primary mechanism for the spread of both wildland and
wildland-urban-interface fires, particularly under dry, hot, and windy conditions during
which the most devastating fires occur. Spotting can lead to rapid fire spread because
firebrands generated by burning vegetation are lofted by the fire plume and transported
downwind to ignite secondary fires or structures far from the flaming fire front. Spotting can create hazardous conditions because people can become trapped between
spot fires with no escape route. Among the many factors that affect spotting are
weather, topography, firebrand properties (energy content at landing, temperature,
smoldering/flaming condition) and ignition propensity of the receptive fuel bed
(moisture content, bulk density, porosity, etc.). Dense short-range spotting may occur
continuously while isolated spots may occasionally be present. In addition to
propagation by firebrand spotting, many wildland fires are initiated by heated metallic
particles (e.g., from conductor clashing, overheated catalytic converters, hot
work/welding, etc.). Although several studies have been conducted regarding
firebrand/heated particle trajectories and physical characteristics at landing, only a few
studies have examined the conditions that can lead to a fire initiation after the landing of
the firebrand or heated metallic particle. Furthermore, no rigorous theoretical models
have yet been developed to analyze this problem. Such theoretical models would
improve the predictive capabilities of physics-based models of fire spread at the
landscape scale. In this presentation the modeling of the embers/metal particles
trajectories and their potential for ignition of a fuel a bed at landing is reviewed. First
the modeling of embers/particles trajectories is visited and summarized. Then the problem of theoretically predicting the conditions for flaming ignition of a fuel bed from a smoldering or flaming ember landing on it is explored. Finally the potential implementation of these models into landscape models of fire spread propagation is discussed.

The problem of the embers or metal particles trajectories has been given considerable attention because knowing how the embers are carried by the wind can lead to a better understanding of how fires are initially started and then spread. In most works published to date numerical models of more or less complexity are developed that predicts how embers of different shapes, (spheres, cylinders and disks) are carried by the wind. These geometrical shapes may be viewed as representative of wood particles, twigs, leaves or shingles. The particles may be initiated at a predetermined height, as in a crowning tree, arcing power lines contacting a tree, a burning wooden structure, or from a fire at ground level where the embers are then lofted by the fire buoyant plume. Plume correlations for axisymmetric and line fires can be used in conjunction with drag coefficients to determine the lofting (vertical) force applied to an ember; similarly, the lateral (horizontal) force components applied on a firebrand or heated particle by ambient winds can be determined through knowledge of drag coefficients and the wind’s velocity profile. Then, calculating the trajectories of embers or particles follows directly from application of Newton’s laws of motion. Simple burning models often based on experimental observations are available to estimate the burn time and temperature of firebrands. Since the embers or particles are burning, consequently their mass decreases with time, which affects both their trajectories and lifetimes. The models generally allow for various terrain conditions and variable wind properties. Various sizes of particles are generally examined. Results show that for particles of equal initial mass, disks flying perpendicular to the wind are carried the farthest by the wind and have the highest remaining mass fraction on ground impact. Spheres carry the shortest distance and cylinders have the smallest mass fraction on impact. For disks in the range of diameters examined, the initial diameter of the disk has no effect on the distance carried in the wind. Various charring and extinction criteria are also examined.

The fact that an ember or metal particle may land burning into a fuel bed does not necessarily implies that it will spot a fire. Multiple conditions affect the problem
such as vegetation bulk density, porosity, humidity, propensity to ignite, etc. The problem is complex and only a few studies have examined the conditions that can lead to fire initiation after the landing of the firebrand or particle. These studies are primarily experimental, and no rigorous theoretical studies have yet been conducted to analyze the problem. Such theoretical models could vastly improve the predictive capabilities of physics-based models of fire spread at the landscape scale, which do not yet have the ability to reliably determine whether or not a firebrand causes a spot fire when it lands. This capability would greatly increase the value of such computer models since their inability to predict spotting makes them unable to reliably simulate fire spread under fire weather conditions conducive to spotting. To help understanding the problem, a preliminary comprehensive 2D numerical model for the potential ignition of a porous fuel bed by an ember or hot metal particle is presented here. The model consists of a computational fluid dynamics (CFD) representation of the gas-phase coupled to a heat transfer and pyrolysis model that simulates condensed-phase phenomena. The coupled model is used to simulate ignition of a powdered cellulose porous fuel bed by glowing pine embers in a laboratory experiment. The model provides qualitative information regarding the mechanisms leading to ignition, smolder, or flame propagation on a porous fuel bed that agree qualitatively with experimental observations. This work provides the foundation for a more complete study of the problem where the effects of different factors (moisture content, humidity, temperature, porosity, particle size/heat content, etc.) are quantified.

The presentation is finished with a brief description of two models of wildland fire propagation, one empirically based and the other CFD based, and their predictive capabilities. A case study where a power line contacting a tree initiated a wildland fire in rugged terrain is presented and discussed.
Extreme Fire Behaviour and Fire Safety

by

Domingos Xavier Viegas

ADAI/LAETA – Department of Mechanical Engineering, University of Coimbra, Portugal

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Abstract

Forest fires behave in complex manner as they can be affected by many factors through mechanisms that are not yet well known and modeled. It is well known that the rate of spread of a fire front and its thermal intensity can vary several orders of magnitude. A sudden change on fire spread conditions can put in danger the lives of either operational personnel or civilians as many accidents in the past and the recent fires in Australia have shown. Extreme fire behaviour is associated to crown fires, to spot fires and to eruptive fires. In this paper a brief mention is made to the two first types of extreme behaviour and more attention is paid to the analysis of eruptive fires. Past experience from the author has shown that practically all major fire accidents, namely those in which multiple fatalities occur are associated to eruptive fires.

A fire eruption consists of a rapid acceleration of the fire front producing very high rates of spread that are associated to very high induced flow velocities and energy released by the fire. An extensive research has been carried out by the author and co-workers in the facilities of the Forest Fire Research Laboratory of ADAI. Tests with different types of fuels in tables that can have the shape of simple slopes or canyons for various configurations were made. In the analysis we use non-dimensional parameters in order to transpose the results obtained at laboratory scale to field scale.

According to our observations a fire eruption is a continuous process that does not have the character of an explosion as it is implied in some interpretations. The acceleration of the fire front is produced by the feedback mechanism of the fire on the surrounding flow as predicted by the mathematical model proposed by Viegas (2005). Fire eruptions are likely to occur in steep slopes and especially in canyons but they can also occur on flat ground in the case of relatively steady wind. The time required for an eruption to develop depends on the initial boundary conditions – topography and wind – but it depends mainly on the fuel bed properties: light fuels like herbaceous having temporal delays of the order of few minutes while heavier fuels like shrubs take fifteen to twenty minutes of delay (Viegas, 2006).
Some case studies are described to illustrate the concepts that are proposed in the present study and to highlight the relevance of this research program to enhance fire safety. These cases include accidents that occurred in Portugal, Spain, Croatia and in the USA. Lessons learned from these cases will be described with the purpose of minimizing future occurrences.

References
DAY TWO

Session 1: Science for firefighting strategies

Session 2: Prediction systems
Biomass burning, as a consequence of wildfires, is a major component of the global biogeochemical cycle. The carbon balance of an ecosystem is altered following a fire through the emission of CO$_2$ and other greenhouse gases and through the production of char.

We can define wildfires as a “cool” burn when the fire only burns vegetation and creates char; but wildfires may also burn into the litter and soils layers and thus release accumulated carbon. We can term these fires “hot”. In practice wildfires will have both “hot” and “cool” spots. If we are to understand the carbon budget of fires we need to understand the fate of carbon in biomass, the litter and the soil and understand its spatial distribution.

Over the Bank Holiday weekend of 23$^{rd}$-26$^{th}$ May 2008, a wildfire occurred on moorland above Edale, Peak District near Grindsbrook Clough. Here we present results of a multi-disciplinary approach to calculating a carbon budget of the fire. The study has surveyed the site of a wildfire and compared results for soils, vegetation, litter and char with results of laboratory experimental burning in order to understand the processes of burning and the fate of carbon reserves.