



## **The Global Palaeo-FIRE Working Group** (Leaders: Mitchell Power, Sandy Harrison)

The palaeo-record provides ideal opportunities for evaluating components of earth system models. Charcoal records from sedimentary contexts provide a way of documenting and exploring past changes in fire regimes. Global syntheses of charcoal data can be used to derive benchmarks for the evaluation of state-of-art coupled vegetation-fire models.

Work carried out by the Palaeofires Working Group during the IGBP Fast-Track Initiative on Fire (2003-2006) has established both the amount of palaeodata available and the usefulness of these data for model evaluation (Power et al., in press; Marlon et al., in prep.). However, the database created by the Palaeofire Working Group established during the Fire FTI currently contains <50% of the available charcoal records worldwide. Continued development of this database would improve the value of this resource for benchmarking activities. The database contains site and sample metadata which, if used in conjunction with information about changes in vegetation distribution, could yield explicit information about vegetation productivity, changes in fuel load and the completeness of burn – all of which would provide a strong constraint on simulated fire regimes and emissions. In combination with archaeological data, the charcoal records can also be used to explore the role of humans in modifying natural fire regimes.

**The Global Palaeo-FIRE Working Group (GPWG)** of the proposed IGBP inter-project **FIRE** activity will:

- Complete construction of the charcoal database
- Document the causes and consequences of changes in fire regimes over the past glacial-interglacial cycle
- Explore ways in which the palaeodata could yield more detailed information on aspects of natural fires
- Provide benchmark data sets to be used in the FIRE-MIP component of the IGBP inter-project FIRE activity
- Explore, in conjunction with the Human-FIRE component of the IGBP inter-project FIRE activity, the role of humans in modifying fire regimes, and the impact of this on vegetation and ultimately on climate itself.

## **Background: the Fast Track Initiative on Fire and the Global Palaeofires Working Group**

Following a ground-breaking workshop on fire held at Isle-sur-la-Sorgue, France under the auspices of the Max Planck Institute for Biogeochemistry, Sandra Lavorel in 2003 proposed an IGBP Fast Track Initiative on Fire. The overarching goal of the Fire FTI was to synthesize quantitative data and understanding of fire-related processes at a global scale. This proposal was accepted by the IGBP Scientific Committee and formed the start of a highly productive activity during an extended (2003-2006) FTI period. The documentation of historical and palaeo fire regimes was the focus of one major strand of the FTI, initiated through a workshop organised by Cathy Whitlock, Tom Swetnam and Mike Flannigan in Boulder, Colorado in 2004. The initial aim of this workshop was to



bring together contemporary fire ecologists and climatologists with experts on tree ring, fire scar and sedimentary charcoal records, with an initial focus on the western USA in order to share data and ideas. This effort built on the International Multiproxy Palaeofire Database that began operation in 2003 and is hosted at NOAA/NGDC. Subsequent work in this area was reported at the December 2004 AGU meeting in multiple sessions on “Fire, Climate, and Ecosystems”, and in an April 2005 workshop on “Fire History and Climate Synthesis in Western North America” in Flagstaff. The realization of the need to create a global synthesis of palaeofire records for model validation led to the formation of the Global Palaeofires Working Group (GPWG) at an FTI meeting in Exeter in October 2005. Initial attempts by the GPWG to informally develop a global database provided the springboard for a larger palaeofire data gathering exercise around an FTI workshop co-sponsored by QUEST (the UK Natural Environment Research Council programme Quantifying and Understanding the Earth System) and held at Dartington Hall, UK in October 2006. This workshop successfully extended the global palaeofire database and used these data to make preliminary evaluations of simulated fire regimes at the Last Glacial Maximum and for the mid-Holocene (see Harrison et al., 2007, *iLEAPS Newsletter*). Thus, as a result of the work of the GPWG during the Fire FTI, there is a strong scientific and organizational structure on which the palaeo-component of the new IGBP cross-project FIRE activity (endorsed by the IGBP Scientific Steering Committee in March 2007) can build.

### **Organization of the GPWG component of the IGBP cross-project FIRE activity**

The activity will be led by Mitchell Power (University of Edinburgh, UK) and Sandy Harrison (University of Bristol, UK). Facilitation of international coordination, and coordination with the International Multiproxy Paleofire Database (IPMD), will be the responsibility of Jenn Marlon (University of Oregon, USA).

Key members of the former FTI have agreed to act as the scientific steering group for the GPWG: Patrick Bartlein, (University of Oregon, USA), Scott Mooney (University of New South Wales, Australia), Cathy Whitlock (Montana State University, USA). Pierre Friedlingstein (LSCE, France), co-leader of the FIRE-MIP component of the IGBP cross-project FIRE activity, will also join the scientific steering group in order to ensure good liaison between the data synthesis and fire modeling activities. Within the scientific steering committee, Cathy Whitlock represents PAGES and Pierre Friedlingstein represents AIMES.

The GPWG built up a global collaborative network through identifying regional coordinators, who then liaise with individual fire scientists working in their region to promote data compilation and to disseminate information about working-group research activities. Discussions at the kick-off workshop in Dartington Hall (October 2007) emphasized the need to preserve some elements of the regional coordinator structure (as



indicated below) but to strengthen the organization by identifying leaders for the other strands of the operational plan.

#### Regional Coordinators

**Europe and northern Africa:** Christopher Carcaillet (Institut de Botanique, Montpellier, France)

**Central and southern Africa:** Carlos Cordova (Oklahoma State University, USA) and Stephen Rucina (National Museums of Kenya, Nairobi)

**North America:** Jenn Marlon (University of Oregon)

**Central and tropical South America:** Francis Mayle (University of Edinburgh, UK)

**Extra-tropical South America:** Patricio Moreno (Universidad de Chile, Chile)

**Asia and the Russia Far East:** Hikaru Takahara (Kyoto Prefectural University, Japan)

**Australasia:** Scott Mooney (University of New South Wales, Sydney)

**Strand 2 Coordinators:** Dan Gavin (University of Oregon, USA), Phil Higuera (University of Montana, USA), Willy Tinner (University of Bern, Switzerland)

**Stand 3 Coordinators:** *to be identified*

**Strand 4 Coordinators:** Sandy Harrison (University of Bristol, UK), Patrick Bartlein (University of Oregon, USA)

## Operational Plan

### *Strand 1: Data Synthesis*

The first objective is to complete the global charcoal synthesis and to make this dataset available as a research tool to the global palaeofire community. Regions identified as significant gaps in the current version of the database will be prioritised for data gathering efforts. The first two targets are Africa and Russia. This activity will require identifying new data contributors and expanding the current network of regional coordinators, but there may also be a need to stimulate new data collection activities in these two regions. We envisage stimulating new research through targeted workshops (in 2008, 2009) to develop capacity-building and networking activities, and to encourage participation in ongoing international activities within Palaeo-FIRE.

The data synthesis activities currently focus on the interval from the Last Glacial Maximum to present. There is potential to extend the temporal focus, at least back to the Eemian interglacial. There are potential synergies here with activities sponsored by the QUAVIDA working group of the ARC-NZ Network for Vegetation Function.

The data synthesis activities will yield maps documenting changes in palaeofire regimes at key times in the past. These maps will be made publicly-available through the IGBP-



AIMES Earth System Atlas initiative. The primary charcoal data and supporting metadata will ultimately be lodged in the International Multiproxy Palaeofire Database.

*Strand 2: Analysis of the causes and consequences of changes in fire regimes over the past glacial-interglacial cycle*

The second major objective is to explain the changes in reconstructed fire patterns through time, by using data syntheses in conjunction with modeling. In the first instance, we will focus on specific time slices, running a coupled vegetation-fire model using simulated palaeoclimate data drawn e.g. from the Palaeoclimate Modelling Intercomparison Project (PMIP). New palaeoclimate simulations for periods identified as showing important changes in fire regimes will allow a fuller range of hypothesis-testing.

The role of humans in modulating the natural fire regime, either by starting or by suppressing fire, is a major focus of the Human-FIRE component of the new IGBP FIRE activity. However, it has a palaeo-dimension: humans have been implicated in major changes in fire regime on both historical and palaeo timescales. By using charcoal data as a target for model simulations, we can explore the role of humans in modifying fire regimes, and the impact of this on vegetation and ultimately on climate itself. This work will be carried out in collaboration with the Human-FIRE group.

*Strand 3: Development of new interpretive tools for charcoal data*

Charcoal records are generally interpreted as recording the incidence of large fires and the magnitude of biomass burning. Work is just beginning on the interpretation of changes in fire incidence as a function of vegetation changes – although there is considerably more that could be done in this area. Under modern conditions, fire regimes are characterized in terms of seasonality, number of fires, intensity of fire (ground versus crown), severity of fire (vegetation mortality), burnt area, and emissions. The inter-relations between these aspects of the fire regime are complex. This makes it important to re-evaluate the palaeo-record and to explore ways in which the palaeodata could yield more detailed information on different aspects of natural fires. This may require incorporating other lines of evidence about the nature of the vegetation into the interpretative model. Conversely, it may require the development of models that simulate charcoal deposition within a particular sedimentary context.

*Strand 4: Provision of benchmark data sets for model evaluation*

A major goal of the project is to provide benchmark data sets for model evaluation. The primary focus of this activity is, naturally, to provide data sets in a timely manner for benchmarking of palaeo-experiments carried out in the FIRE-MIP component of the IGBP inter-project FIRE activity. However, with ongoing development of earth-system models, these data sets will continue to be a resource for the modeling community as a whole.



## Implementation

GPWG activities will be carried forward through a series of workshops. These workshops will be designed to allow specific tasks to be carried out (e.g. data collection and analysis, evaluation of model output, writing). Our experience from the Dartington Hall workshops shows that it is possible to achieve concrete products in workshop mode. We will complement these workshops by using more conventional opportunities to present/discuss fire-related research at conferences, and by organizing symposia or sessions of palaeofire at major international conferences (e.g. EGU, AGU, INQUA).

The kick-off workshop for the new phase of the GPWG was held in October 2007 at Dartington Hall, Totnes, UK and was funded by QUEST, PAGES and iLEAPS.

We plan to hold the following workshops during 2008-2012:

1. October 2008: Nairobi, Kenya.  
*Workshop theme: Palaeofires in Africa.* The aim of the workshop is to strengthen collaborations with African scientists. We will use this as an opportunity to locate/collect data from the continent, to identify significant gaps in data coverage (through detailed examination of model predictions), to discuss the role of anthropogenic fire regimes on palaeo timescales. The workshop may have a significant capacity-building component and it is hoped that it will trigger new work on palaeofire across the continent.  
*Strand 1*  
*Scientists in charge of organization: Carlos Cordova, Sandy Harrison, Mitchell Power, Stephen Rucina*  
*Potential Funding Sources: START, PAGES, UK Overseas Development Funds*
2. November(?) 2008: Punta Arenas, Chile  
*Workshop theme: Interpreting the charcoal record* This workshop will explore new methods of interpreting the charcoal data, making use of the database to test these ideas. Key questions that will be addressed include: What do charcoal data mean at different spatial scales? How do differing charcoal methodologies influence interpretations about fire occurrence?.  
*Strand 3*  
*Scientists in charge of organization: Patricio Moreno, Cathy Whitlock*  
*Potential Funding Sources: IAI, NSF*
3. May, 2009: Eugene, Oregon, USA  
*Workshop theme: State-of-the-art palaeofire analysis*  
The workshop will bring together a wide range of data analyses techniques and expertise used to interpret fossil charcoal data. The aim of the workshop will be to develop appropriate data analysis techniques for any given site type, sampling resolution, and palaeovegetation.



*Strand 3*

*Scientists in charge of organization: Patrick Bartlein, Dan Gavin*

*Potential Funding Sources: NSF*

4. August, 2009: Odessa, Russia

*Workshop theme: Palaeofires in the boreal zone since the Last Glacial Maximum.*

The workshop will focus on building up contacts in Russia, on continued acquisition of palaeofire data from Russia and the northern extratropics, and on examining changes in fire regimes in the boreal forest zone since the LGM based on data and model simulations. We will use this as an opportunity to locate/collect data from the continent, to identify significant gaps in data coverage (through detailed examination of model predictions)

*Strand 1*

*Scientists in charge of organization: to be identified*

*Potential funding sources: START, IIASA, PAGES*

5. January 2010: Paris, France (Joint workshop with FIRE-MIP)

*Workshop theme: Evaluation of the FIRE-MIP palaeofire simulations.*

The goal of this workshop will be to conduct regional-scale evaluation of the models participating in FIRE-MIP on palaeo-timescales based on the charcoal data.

*Strand 4*

*Scientists in charge of organization: Sandy Harrison, Pierre Friedlingstein*

*Potential Funding Sources: tbc*

6. September 2010: Canberra, Australia (Joint workshop with Human-FIRE and the QUAVIDA working group)

*Workshop theme: The Human Use of Fire.*

The aim of this workshop is to explore the impact of anthropogenic fire regimes on vegetation and climate, focusing on times and places in the palaeo-record when humans are thought to have had a significant impact on the landscape through their use of fire.

*Strand 2*

*Scientists in charge of organization: to be identified*

*Potential Funding Sources: ARC-NZ Network for Vegetation Function*

7. September 2011: Aussois, France

*Workshop theme: Fire and the global carbon cycle, applications of palaeofire simulations and charcoal data.*

*Strand 2*

*Scientists in charge of organization: Chris Carcaillet, Colin Prentice*

*Potential Funding Sources: tbc*

In addition to these workshops, we envisage holding an “open science meeting” in the early part of 2012 to bring together all members of the GPWG and showcase progress achieved in this area of research as a result of the GPWG.



## **Deliverables**

1. A comprehensive global charcoal database that spans the geologic record from modern to Eemian times.
2. Creation of a web-based interface that can be easily accessed and used by a variety of global change scientists (including both palaeodata experts and modelers) to query the global charcoal database by specific region or time span.
3. Benchmark data sets for use in FIRE-MIP
4. Publication of peer-reviewed manuscripts that present the palaeofire database, fire simulations, and regionally and/or thematically focused research topics.
5. Publication of both palaeofire data and simulations in the IGBP Earth System Atlas for use in scientific research, to aid in policy decisions, and provide the public with access to scientific data.

## **Funding Implications**

The planned activities require long-term funding support for the lead coordinator (Mitchell Power) and for a database manager. We have funding support for these roles through to mid-2008 from the QUEST programme, and anticipate seeking further research funding for support after this from UK, US and European funding sources.

The major implementation mode for GPWG will be through regular, targeted workshops as listed above. We anticipate funding these workshops in part through IGBP and in part through applications to other appropriate sources (as indicated above).