Fire in the Earth System: The Global Palaeofire Working Group

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Fire is the most ubiquitous disturbance affecting terrestrial ecosystems and has significant impacts on atmospheric chemistry and the global carbon cycle. Even though modern fire regimes are strongly influenced by human activities, the occurrence and magnitude of fires are largely controlled by climate and characteristics of the vegetation cover. The same is true of paleo-fire regimes: humans have used fire as a tool for land clearance and to improve agricultural and grazing land, but the charcoal record shows that on millennial time-scales fire regimes respond to changes in regional climates and climate-induced vegetation changes. However, the interactions between climate, vegetation and human activities are complex and much remains to be done to understand how these factors have influenced fire regimes during the Quaternary. The Global Palaeofire Working Group (GPWG) is providing the tools that will help elucidate these relationships.

The GPWG was formed as part of the IGBP Fast-Track Initiative on Fire and is now part of the IGBP Cross-Project Initiative on Fire. The goals of the GPWG are to collect sedimentary charcoal records and to use these records to analyze the underlying causes of changes in regional fire patterns in the late Quaternary. The GPWG database includes records of charcoal from a variety of sedimentary sequences, including lakes, bogs and soils. The database includes descriptive data about each site (e.g., site type, hydrology), about individual charcoal samples (e.g., sample size, sampling method, size of material counted), and about the chronology of each record. Version 1 of the database (www.bridge.bris.ac.uk/projects/QUEST_IGBP_Global_Palaeofire_WG) contains 405 sites, with representation from every continent (Fig. 1).

The GPWG database has been used to analyze the patterns of changes in fire regimes since the Last Glacial Maximum (LGM) (Power et al., in press; Fig. 1). This analysis shows that there is strong broad-scale coherence in fire activity at the LGM and during the deglaciation, while the Holocene records show greater spatial heterogeneity. Charcoal records from

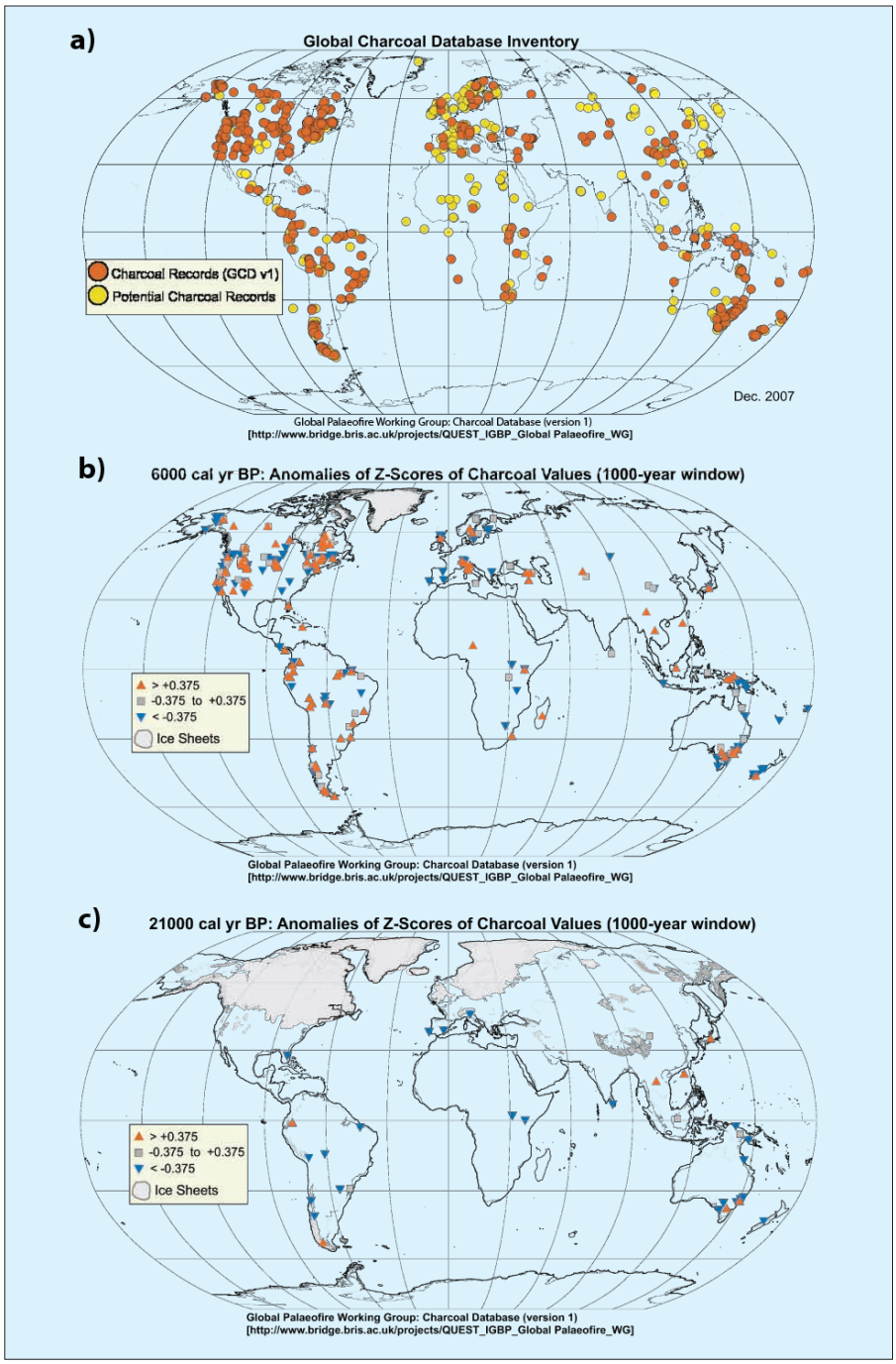

*Figure 1: **a**) global distribution of sites in the charcoal database; **b**) 6 kyr BP minus present (0 kyr) charcoal abundance differences; and **c**) 21 kyr minus present charcoal abundance differences. Distribution of red colored sites (a) represents sites (n = 405) used in first global synthesis (Power et al., in press), gray colored sites are additional records identified since the release of Global Charcoal Database (GCD) version 1. Number of sites shown represents a snapshot of database. Charcoal data used to create the charcoal anomaly maps are heterogeneous, reflecting the range of laboratory and data-analytical methods used to describe charcoal abundance variations over time. Charcoal values contained within the GCD range over 13 orders of magnitude and required a standardization protocol for the recently published global syntheses and subsequent syntheses efforts. Individual records analyzed by: (1) rescaling whole record to range between 0.0-1.0; (2) rescaled values then transformed using Box-Cox transformation to approach normality where possible, where the transformation parameter estimated using maximum likelihood; (3) transformed values were standardized or converted to Z-Scores using mean and standard deviation for each record over the interval from 4000-100 cal yr BP; (4) anomalies were calculated as the difference between the mean of Z-scores for the intervals 6.5-5.5 cal kyr BP (b) or 21.5-20.5 cal kyr BP (c) and those for interval 1000-100 cal yr BP (not shown).*

extratropical regions of North America, Europe and South America indicate reduced fire activity during the deglaciation (21~11 cal kyr BP). The tropical latitudes of South America and Africa show increased fire activity from ~19-17 cal kyr BP, as do most sites from Indochina and Australia between 16-13 cal kyr BP. Many sites indicate increased fire activity during the Holocene, although fire activity was reduced in eastern North America and eastern Asia between 8 and ~3 cal kyr BP, Indonesia and Australia between 11 and 4 cal kyr BP, and in southern South America between 6-3 cal kyr BP.

Comparison of the charcoal-based reconstructions with other paleoclimatic records suggests explanations for the reconstructed changes in fire regimes (see Power et al., in press), but diagnosing the underlying causes of these changes requires modeling of the coupled vegetation-fuel-fire system. The GPWG is currently using LPJ-SPITFIRE—a coupled dynamic global vegetation-fire model (Thonicke et al., subm)—to examine the impact of mid-Holocene (ca. 6 cal kyr BP) and the LGM (ca. 21 cal kyr BP) climates on vegetation and fire. These simulations, driven by climate output from coupled ocean-atmosphere general circulation models from the Palaeoclimate Modelling Intercomparison Project (PMIP2), show surprisingly good matches to the reconstructed fire regimes.

At a workshop in October, sponsored by the UK NERC-sponsored QUEST (Quantifying and Understanding the Earth System) program, iLEAPS and PAGES, members of the GPWG mapped out their future activities. These include: (1) continued expansion of the charcoal database, (2) analysis of the causes and consequences of changes in fire regimes over the last interglacial-glacial-interglacial cycle, (3) development of new interpretive tools, and (4) creation of benchmark model-evaluation data sets for the Fire Model Intercomparison Project (FIREMIP). The GPWG currently has over 90 members worldwide, and welcomes participation by all scientists interested in understanding the role of paleofire in the Earth System.

References

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Mangrove paleoecology and environmental change

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Cairns, Australia was a most appropriate venue for a research session dedicated to mangrove paleoecology. Held at the INQUA 2007 meeting, the session was supported by PAGES and the US NSF. Mangrove ecosystems are productive and important economic resources for people living in tropical coastal areas. They are also highly susceptible to sea level changes and can form protective barriers against wind, flooding, erosion and tsunami damage. Information on past mangroves is imperative in understanding the effects of present and possible future ecological changes. The mangrove paleoecology session brought together researchers studying how mangroves respond to environmental changes. A further objective of the session was to promote the representation of researchers from developing countries, where mangroves are important ecosystems. Towards this goal, PAGES funds supported two researchers (Marcelo Cohen, Brazil and Sauren Das, India) to attend the meeting.

Figure 1: A Rhizophora mangle *(red mangrove) tree off the coast of Belize, Central America. A number of presentations in the session illustrated the abilities of mangroves to track and respond to sea level changes. For instance, stands dominated by* R. mangle *have been able to maintain mangrove habitats off the coast of Belize for at least the last ~8,000 years of sea level changes. (photo: M. Wooller).*

The session, which consisted of four sub-sessions over two days, was co-convened by Matthew Wooller, Hermann Behling, Simon Haberle and Marcelo Cohen and consisted of oral and poster presentations. With study sites included from Brazil, Belize, India, New Zealand, Indonesia and Australia, the session succeeded in its objective to provide a pan-tropical perspective of mangrove paleoecology. The session also succeeded in providing examples of the diverse array of paleoecological techniques needed to understand past mangrove ecological changes.

Patrick Moss began the session with a record from ODP 820 marine core (north-eastern Australia) of mangrove paleoecology covering the last million years. James Westgate and Carole Gee followed with faunal and floral ecological reconstructions from the middle Eocene mangroves in Texas. Although these two talks fell outside the Quaternary theme they provided valuable perspectives of mangrove antiquity and the challenges associated with