Veget Hist Archaeobot (2008) 17:415–418
DOI 10.1007/s00334-008-0170-x

EDITORIAL

Human impact on terrestrial ecosystems, pollen calibration and quantitative reconstruction of past land-cover

Marie-José Gaillard · Shinya Sugita · Jane Bunting · John Dearing · Felix Bittmann

Published online: 11 July 2008

The first joint HITE-POLLANDCAL conference in Umeå, Sweden, 13–14 November 2005 on "Human impact on terrestrial ecosystems on long to short-term scales with an emphasis on pollen calibration and quantitative reconstruction of past land-cover changes" forms the basis of the papers published in this special issue of *Vegetation History and Archaeobotany*. The conference was initiated by the POLlen-LANDscape CALibration (POLLANDCAL) Network sponsored in 2001–2005 by NordForsk (formally NorFA, the Nordic Research Council) (http://www.ecrc.ucl.ac.uk/pollandcal) in order to disseminate and link more securely the POLLANDCAL initiative to the IGBP Focus 5 HITE (Human Impacts on Terrestrial Ecosystems) activities (Oldfield et al. 2000).

We dedicate this special issue to Margaret Davis, who was the pioneer in pollen-vegetation calibration (Davis 1963; Davis and Deevey 1964) and constantly pushed pollen analytical research ahead of the front-line of palaeoecological research; to Svend Th Andersen, who formally formulated the importance of long-distance pollen into the pollen-vegetation relationship (Andersen 1970)—an important step to the recent advances in theory and practice on the subject (Parsons and Prentice 1981; Sugita 2007b); to Jim Ritchie, who supported and contributed with great enthusiasm to the production of the special issue of *Review of Palaeobotany and Palynology* on "Modern pollen rain and fossil pollen spectra" (Gaillard et al. 1994) and for his inspiring pioneer work on pollen-vegetation relationships (for example, Lichti-Federovich and Ritchie 1968; Ritchie and Yarranton 1978); to Björn Berglund, who began the first studies of pollen-vegetation relationships in human-induced landscapes of Europe (Berglund et al. 1986) and encouraged further research projects on the subject; to Frank Oldfield, for including the research efforts in pollen calibration into the IGBP-PAGES (Past Global Changes) framework and its Focus 5 on human dimensions, for always supporting and believing in the efforts of POLLANDCAL and HITE, and for his wise views on the potential of palaeoecological science as a whole; to Brigitta Ammann, for her constant support, interest, enthusiasm and open mind through the years of research on past human-induced vegetation and landscape change; and to Sheila Hicks, for her invaluable support and help in all initiatives to promote research on pollen-vegetation calibration, for supporting the idea of a NorFA network and helping in its realisation, and making it a wonderful experience for all of us.

In 1992, a special session on "modern pollen rain and fossil pollen spectra" was organised at the 8th International Palynological Congress (IPC) at Aix-en-Provence in France. It was dedicated to the use of modern pollen-vegetation-environment relationships in the interpretation

M.-J. Gaillard (✉)
School of Pure and Applied Natural Sciences,
University of Kalmar, Kalmar 39182, Sweden
e-mail: marie-jose.gaillard-lemdahl@hik.se

S. Sugita
University of Minnesota, Ecology, Evolution, and Behavior,
100 Ecology Building, 1987, Upper Buford Circle,
St Paul 55108, MN, USA

J. Bunting
Department of Geography, University of Hull,
Kingston-upon-Hull HU6 7RX, UK

J. Dearing
Department of Geography, University of Liverpool,
Roxby Building, Liverpool L69 7ZT, UK

F. Bittmann
Lower Saxony Institute for Historical Coastal Research,
Viktoriastr. 26/28, 26382 Wilhelmshaven, Germany

of fossil pollen spectra. In their preface, the editors of the special issue presenting papers from that session (Gaillard et al. 1994) wrote: “The tempo and scope of research in pollen analysis have increased significantly recently, in response to the twin challenges of the need to understand better the nature of climate change and the need to acquire more precise knowledge about the nature of past human effects on the landscape. The current intensified awareness of the actual and potential ecological problems that confront us, sometimes on global scales, has propelled those disciplines concerned with the past on to central positions of the scientific stage. [….] It became increasingly apparent that the important quantitative link between pollen spectrum and vegetation at the finer, landscape scale was missing. But it became equally clear that this problem of scale, lucidly presented by Birks (1986), must be solved if pollen analysis was to be used to unravel the nature of ecological changes on particular landforms within a broader geographical region.” Today, 16 years later, we have a much better understanding of the spatial scale of vegetation reconstructions inferred from pollen records (Sugita 1994), as well as a concept and a method to quantify past vegetation based on current knowledge and understanding of the pollen-vegetation relationship (Sugita 2007a, b). The “Landscape Reconstruction Algorithm” (LRA) introduced by Sugita (2007a, b) includes two model-based steps. The REVEALS (Regional Estimates of Vegetation Abundance from Large Sites) model estimates vegetation at the regional scale (>10^3 km^2), using fossil pollen from large sites >100 ha. The LOVE (Local Vegetation Estimates) model reconstructs vegetation at the local scale (ca. 1–10 km^2) using pollen records from smaller sites. It is now possible to estimate the percentage cover of major trees and herbs at both the regional and local scales in Europe, northern America and southern Africa, where estimates of pollen productivity, one of the most important parameters in the models, have become available for major plant taxa.

After the IPC in 1992, several projects on pollen–vegetation relationships were initiated in Europe and other parts of the world. The need to provide pollen-based quantitative reconstructions of land cover was emphasised by Frank Oldfield to enhance the interactions between the IGBP PAGES and IHDP LUCC (LAND USE COVER and CHANGE) programmes, as well as in the development of the HITE activity within the IGBP Focus 5 on Ecosystem Processes and Human–Environment Interactions during the second half of the 1990s. BIOME 300 (Leemans et al. 2000) was a joint initiative of LUCC and PAGES with two major objectives: (1) a short-term objective, to produce coordinated databases and revised land-cover maps at 50-year intervals from A.D. 1700, and (2) a long-term objective, to build a community for a long-term effort to reconstruct and understand human impacts on the landscape over the past several millennia. The goal of HITE (Oldfield et al. 2000) was to “define and to promote research on key issues relating to human impact and natural environmental change. […] HITE aims to promote rigorous and integrated methodologies in which ecologists, modelers, environmental historians and palaeoecologists may work profitably together”.

The POLLANDCAL network had the major aim to develop and apply powerful tools to the study of the pollen–vegetation relationship to produce reliable quantitative reconstructions of past vegetation and landscapes, at the same time making an important contribution to the HITE objectives. The network is still active today and works with collaborative projects within various constellations of POLLANDCAL members together with scientists from other disciplines and research groups. POLLANDCAL’s research strategy is based mainly on a simulation approach to clarify the pollen–vegetation relationship considering interspecific differences in pollen dispersal and deposition and realistic spatial distribution of source plants in the landscape (Sugita 1993, 1994; Sugita et al. 1999). User-friendly software was developed for the application of these models (Middleton and Bunting 2004; Bunting and Middleton 2005), and a large number of simulation experiments were performed to obtain insights on pollen–vegetation relationships and their significance for the interpretation of pollen records. Moreover, several studies focused on estimating pollen productivity in different regions, and some tested the REVEALS model (Hellman et al. 2008; Soepboer et al. 2008) to reconstruct regional vegetation in different regions of Europe.

The present issue is divided into two sections. The first section comprises eight papers dealing with major achievements of the POLLANDCAL network and related issues, while the second section is a collection of six papers relating to various human-induced vegetation and landscape changes. In the first section, Gaillard et al. present the POLLANDCAL network’s research strategy together with some examples of studies using the modelling approach. Hellman et al. test the REVEALS model of Sugita (2007a) with the major aim of giving useful recommendations to users of the model. The paper by Broström et al. is a compilation and evaluation of all pollen productivity estimates (PPEs) now available for Europe. It is followed by contributions dealing more specifically with PPEs in the Jura Mountains (Mazier et al.), on the Swiss Plateau (Soepboer et al.), and in southern Africa (Duffin and Bunting). Poska et al. propose a methodology to produce maps of past cultural landscapes, and finally Caseldine et al. discuss the potential of combining pollen modelling, palaeoecological and archaeological data to visualise past cultural landscapes. In section two, the paper by Grant et al. presents an example of human-induced landscape, the New Forest in Britain, and discusses ways to use palaeoecological studies and results in conservation projects and future management of landscapes. Dahlström exemplifies the use of historical records to reconstruct grazing dynamics at various spatial and temporal scales. Berglund et al. present an attempt at reconstructing long-term changes in floristic and landscape diversity, and discuss the implications and limits of the method. Gaudin et al. show the potential of multi-proxy databases with an example from north-western France including pollen data, archaeological and physical factors. Bradshaw proposes a data-model comparison approach as a possible way to detect past human impact on vegetation in pollen records. Finally, the study by Olofsson and Hickler explores the possible effects of human land-use on the global carbon cycle during the last 6,000 years by estimating past land cover using population growth modelling.

Palaeoenvironmental reconstructions are critical to develop and evaluate predictive models of climatic and environmental change. Comparison of model outputs with empirical data is necessary to refine models (Anderson et al. 2006; Dearing 2006), but is also useful to understand processes behind empirical data in more depth (e.g. the PMIP program, http://pmip.lsce.ipsl.fr). Because climate modellers are increasingly turning their attention to the processes governing changes in the land surface and its coupling to the atmosphere (e.g. Denman et al. 2007; Meehl et al. 2007), there is a growing need to supplement palaeoclimate reconstructions with new syntheses of data records at *global-continental scales* to test theories on climate–ecosystem–human interactions, to improve mechanistic understanding for incorporation in predictive models and to strengthen the knowledge basis of human–environment interactions (e.g. Dearing 2006; Denman et al. 2007). The long-term land-cover data is generally inferred from estimates of population density through time (e.g. Brovkin et al. 2006; Olofsson and Hickler this volume). Existing databases of global estimates of land-use change back to A.D. 1700 (Klein Goldewijk and Ramankutty 2004; Klein Goldewijk 2001; Ramankutty and Foley 1999) are derived by linking recent remote sensed images and land census data to past human population censuses. Brovkin et al. (2006) use these databases to reconstruct land-use feedbacks on climate over the past 1000 years, but due to the lack of palaeodata synthesis of past land cover, the decrease in forest cover between A.D. 1000 and 1700 was assumed to have occurred at a constant rate. Today, thanks to the achievements of the POLLANDCAL network and related research projects, and thanks to the REVEALS and LOVE models (Sugita 2007a, b), pollen records from large and small basins can be used to reconstruct past vegetation quantitatively at both the regional and local spatial scales. This opens up the possibility of achieving a considerably more robust assessment of human land-use throughout the Holocene (Anderson et al. 2006; Gaillard 2007). Holocene records of global land cover or biomass would allow improved estimations of the contribution by loss of woodland/land use change to greenhouse gas emissions, including testing hypotheses such as Ruddiman's (2003) early-anthropogenic hypothesis. Ruddiman's (2007) latest paper summarises deforestation in different regions of the world, but uses data generated from the environmental history community: palynological data are effectively rejected.

In the new implementation plan of IGBP PAGES, the former Focus 5 is replaced by Focus 4 "Past Human-Climate-Ecological Interactions (PHAROS)". The PHAROS programme was formally adopted in August 2007 and its principal objective is to bring together existing and new research communities to examine how climate, natural ecosystems and human activity have interacted through time both regionally and globally, and how these findings help address key questions about future global environmental change. The existing HITE, LIMPACS and LUCIFS programmes have been extended to include an over-arching INTEMODS programme that aims to promote cross-cutting integration and modelling activities. A goal of Hite is now to provide regional/local synthese of land cover through the Holocene in useful formats for modelling studies to examine the vegetation–human–climate relationships, deliverable within the PAGES science and implementation plan by 2009/10. The application of REVEALS and of the PPEs available to date, as well as the insight and expertise gained through the POLLANDCAL network activities will form an important part of the HITE programme during the coming years.

Besides the colleagues and friends to whom we are dedicating this issue, we wish to thank here all colleagues and friends that have made both research progress and this special issue possible, especially all POLLANDCAL members for their burning interest in the topic and marvellous collaboration and group spirit through the years of network, more particularly Anna Broström for suggesting that we should apply for a NorFA network and for her continuous help and enthusiasm throughout the POLLANDCAL activities, Jane Bunting and Dick Middleton for developing user-friendly software, Heather Binney for taking care of and updating the network's homepage, Welmoed Soepboer for putting together our Newsletters, Chris Caseldine for helping with editing the Newsletters and many of our papers, and all members who organised the twelve workshops in various parts of Europe. Finally we want to thank Ulf Segerström, Henrik von Stedingk and Anna Karlsson for organising the HITE-POLLANDCAL conference in Umeå in November 2005. We acknowledge the financial support of NordForsk (formely NorFA), the Swedish Research Council (VR—Vetenskapsrådet) and the Faculty of Natural Sciences and Engineering of Kalmar University.

References

Andersen ST (1970) The relative pollen productivity and pollen representation of North European trees and correction factors for tree pollen spectra. Danmarks Geologiske Undersøgelse, Række II, p 96

Anderson NJ, Bugmann H, Dearing JA, Gaillard M-J (2006) Linking palaeoenvironmental data and models to understand the past and to predict the future. Trends Ecol Evol 21:696–704

Berglund BE, Emanuelsson U, Persson S, Persson T (1986) Pollen/vegetation relationships in grazed and mowed plant communities of South Sweden. In: Behre KE (ed) Anthropogenic indicators in pollen diagrams. Balkema, Rotterdam, pp 37–52

Birks HJB (1986) Late-quaternary biotic changes in terrestrial and lacustrine environments, with particular reference to northwest Europe. In: Berglund BE (ed) Handbook of Holocene palaeoecology and palaeohydrology. Wiley, Chichester, pp 3–65

Brovkin V, Claussen M, Driesschaert E, Fichefet T, Kicklighter D, Loutre MF, Matthews HD, Ramankutty N, Schaeffer M, Sokolov A (2006) Biogeophysical effects of historical land cover changes simulated by six Earth system models of intermediate complexity. Clim Dyn 26:587–600

Bunting MJ, Middleton R (2005) Modelling pollen dispersal and deposition using HUMPOL software, including simulating windroses and irregular lakes. Rev Palaeobot Palynol 134:185–196

Davis MB (1963) On the theory of pollen analysis. Am J Sci 261:897–912

Davis MB, Deevey ES Jr (1964) Pollen accumulation rates: Estimates from late-glacial sediment of Rogers Lake. Science 145:1293–1295

Dearing JA (2006) Climate-human-environment interactions: resolving our past. Clim Past 2:187–203

Denman KL, Brasseur G, Chidthaisong A, Ciais P, Cox P, Dickinson RE, Haugustaine D, Heinze C, Holland E, Jacob D, Lohmann U, Ramachandran S, a Dias PL, Wofsy SC, Zhang X (2007) Couplings between changes in the climate system and biogeochemistry. In: Solomon S, Qin D, Manning M, Chen Z, Marquis M, Averyt KB, Tignor M, Miller HL (eds) Climate change 2007: the physical science basis Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, pp 499–587

Gaillard MJ (2007) Archaeological applications. In: Elias SA (ed) Encyclopedia of quaternary science. Elsevier, Amsterdam, pp 2570–2595

Gaillard MJ, Hicks S, Ritchie JC (eds) (1994) Modern pollen rain and fossil pollen spectra. Rev Palaeobot Palynol 82, Elsevier, Amsterdam

Hellman S, Gaillard M-J, Broström A, Sugita S (2008) The REVEALS model, a new tool to estimate past regional plant abundance from data in large lakes: validation in southern Sweden. J Quatern Sci 23:1–22

Klein Goldewijk K (2001) Estimating global land use change over the past 300 years: the HYDE database. Global Biogeochem Cycles 15:417–434

Klein Goldewijk K, Ramankutty N (2004) Land cover change over the last three centuries due to human activities: the availability of new global data sets. Geojournal 61:335–344

Leemans R, Tompson RS, Oldfield F (2000) BIOME 300—a joint initiative of LUCC and PAGES. PAGES Newsletter 2000–3:32

Lichti-Federovich S, Ritchie JC (1968) Recent pollen assemblages from the Western Interior of Canada. Rev Palaeobot Palynol 7:297–344

Meehl GA, Stocker TF, Collins WD, Friedlingstein P, Gaye AT, Gregory JM, Kitoh A, Knutti R, Murphy JM, Noda A, Raper SCB, Watterson IG, Weaver AJ, Zhao Z-C (2007) Global climate projections. In: Solomon S, Qin D, Manning M, Chen Z, Marquis M, Averyt KB, Tignor M, Miller HL (eds) Climate change 2007: the physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, pp 747–845

Middleton R, Bunting MJ (2004) Mosaic v1.1: landscape scenario creation software for simulation of pollen dispersal and deposition. Rev Palaeobot Palynol 132:61–66

Oldfield F, Dearing JA, Gaillard M-J, Bugmann H (2000) Ecosystem processes and human dimensions–the scope and future of HITE (human impacts on terrestrial ecosystems). PAGES Newsletter 3:21–23

Parsons RW, Prentice IC (1981) Statistical approaches to R-values and the pollen-vegetational relationship. Rev Palaeobot Palynol 32:127–152

Ramankutty N, Foley JA (1999) Estimating historical changes in global land cover: croplands from 1700 to 1992. Global Biogeochem Cycles 13:997–1027

Ritchie JC, Yarranton GA (1978) The Late-Quaternary history of the Boreal Forest of Central Canada, based on standard pollen stratigraphy and principal component analysis. J Ecol 66:199–212

Ruddiman WF (2003) The anthropogenic greenhouse era began thousands of years ago. Clim Change 61:261–293

Ruddiman WF (2007) The early anthropogenic hypothesis: challenges and responses. Rev Geophysics 45:1–37

Soepboer W, Sugita S, Lotter A (2008) Modelling regional vegetation changes on the Swiss Plateau during the past two millennia. Quatern Sci Rev

Sugita S (1993) A model of pollen source area for an entire lake surface. Quatern Res 39:239–244

Sugita S (1994) Pollen representation of vegetation in quaternary sediments: theory and method in patchy vegetation. J Ecol 82:881–897

Sugita S (2007a) Theory of quantitative reconstruction of vegetation. I. Pollen from large sites REVEALS regional vegetation. Holocene 17:229–241

Sugita S (2007b) Theory of quantitative reconstruction of vegetation. II. All You Need Is LOVE. Holocene 17:243–257

Sugita S, Gaillard M-J, Broström A (1999) Landscape openness and pollen records: a simulation approach. Holocene 9:409–421