Eco-cultural Niche Modeling
An OMLL - NSF symposium
Les Eyzies, 22nd-26th september 2005

OMLL
A EUROCORES PROGRAMME
EUROPEAN SCIENCE FOUNDATION COLLABORATIVE RESEARCH

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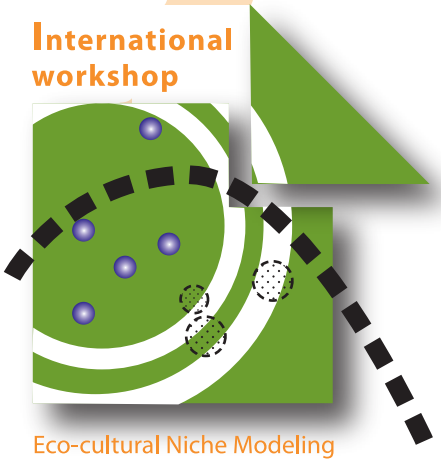

Exploring the potential of Eco-cultural Niche Modeling for reconstructing the geography of past human populations

An OMLL-NSF symposium

Programme

Thursday, September 22

2:00-5:30pm Arrival of participants (including pick-up from Bordeaux)
A bus will leave the airport for Les Eyzies at 3pm and participants are required to arrive at the Bordeaux airport before then. Those arriving at the Bordeaux railway station or arriving at Les Eyzies by other transportation are asked to inform Francesco d'Errico.

6:00 – 7:30pm Reception at the Maison François Bordes, Les Eyzies.

Dinner on own in Les Eyzies

Friday, September 23 (Auditorium of the Musée National de Préhistoire)

9:00-9:45am Introductory Remarks
Welcome by the director of the Musée National de Préhistoire (*Cleyet-Merle*)
Remarks by representatives of EUROCORES, OMLL, NSF
Overview of the workshop, its purpose and goals *(Krishtalka, West, d'Errico, Dibble)*

9:45am Break

10:00-12:30am Theoretical Bases and Demonstration of Eco-Cultural Niche Modeling Software

Introduction to Ecological Niche Modeling: Using Fragmentary Occurrence Information to Reconstruct Potential Geographic Distributions *(Peterson)*—10:00-10:45
Energetics of early hominids on early landscapes *(Porter)*—10:45-11:15
Summary of the Lawrence 2003 meeting *(GARP working group)*—11:15-12:00

12:30-2:00pm Lunch (Chez Jugie at Laugerie Haute).

A bus will take the participants to the restaurant located 2 km from the Museum.

2:00-4:30pm Applications and Preliminary Results of Eco-Cultural Niche Modeling

Applications and Preliminary Results of Eco-Cultural Niche Modeling *(Anderson, Gillam, Caithness and Peterson)*—2:00-2:30
Solutrean (*Bank, Montet-White, Peterson, d'Errico, Vanhaeren*)—3:00-3:30
Acheulean (*Goren et al*.) 3:30-4:00

4:00pm Break

4:15pm Culture and climate. Case studies

Integrating spatial and temporal dynamics in ecological modeling: issues and directions (*Barton)*- 4:15-4:35
The Impact of the H4 Event on Neanderthal Extinction and Aurignacian Colonization of Iberia (*Sepulchre, et al.)* -4:35-4:50
The Impact of the D/O Climatic Variability on Upper Paleolithic Populations (*d'Errico, et al*.)- 4:50-5:10
The Cultural Geography of Upper Paleolithic Populations. Interactions among Chronological, Cultural and Palaeoecological Data *(Vanhaeren et al.)*—5:10-5:30

5:30pm Break

5:45-6:15pm Discussion
Prospects and Problems in the Application of Eco-Cultural Modeling to Human Populations.

6:30 Visit at Abri Pataud Museum

8:00 Dinner at the restaurant "Le Chateaubriant"

Saturday, September 24, 9:00am

Overview Discussions of Available Data Potentially Relevant to Hominid Eco-Modeling.

Chronology and Paleoenvironment

C14: state of the Art (*Menot-Combe*)—9:00-9:30
The Last Climatic Cycle, the Continental Record (*Wohlfarth)*-- 9:30-10:00
The Last Climatic Cycle, the Global Record *(Sanchez Goni)*—10:00: 10:30

10:30-10:50 Break

Archaeozoology/Paleontology

A paleontological Database for the OIS2-3: Large Mammals biodiversity and biogeography factors (*Brugal, Escarguel, Legendre*)—10:50-11:20

A Fourth-Corner based method to infer palaeoenvironments from fossil assemblages: the example of north-equatorial African Holocene Bovids (*Jousse and Escarguel*))—11:20-11:50

11:50-12:10 Discussion

12:30-2:00 Lunch (Chez Jugie at Laugerie Haute).
A bus will take the participants to the restaurant.

Paleoenvironmental Modeling

Paleoclimatic databases (*Caspar Amman)* —2:00-2:20
Paleoclimatic Modeling (*Ramstain or Masa Kagayama*) —2:20-2:40
Paleovegetation Modeling (*Crucifix*) —2:40-3:00

Physical Anthropology: Human Paleontology

The Concept of Species and Population in Human Genetics, Biological Anthropology and Paleoanthropology (*Maureille*) —3:00-3:20
Models for the Dispersal of *Homo erectus (Hughes)* —3:20-3:40
Models for the Dispersal and Extinction of Hominid Populations and their Testability (*Foley and Field*) 3:40-4:00

4:00-4:20 Break

Human Genetics and Demography

Spatial Rendering of Genetic Data in Conjunction with Eco-Cultural Modeling (*Schurr*)—4:20-4:40
Early Upper Pleistocene Demographics (*Jones*) – 4:40 – 5:00

Archaeology

The Concepts of Prehistoric Culture, Technocomplex and Technical Systems in the Lower and Middle Palaeolithic: Their Applicability to Eco-Cultural Niche Modeling (*Dibble, Turq, Olszewski, Jaubert*)— 5:00-5:30
The Concepts of Prehistoric Culture, Technocomplexes and Technical Systems in the Upper Palaeolithic. Their Applicability to Eco-Cultural Niche Modeling (*Svoboda, Jaubert*) —5:30-6:00
Models of Human Colonization (*Steele*) 6:00-6:30
Palaeolithic "cultures" in Africa and Europe. What is the difference? (*Brooks, Yellen*)—6:30-7:00

7:00 Reception at the Les Eyzies Museum

Dinner on own in Les Eyzies

Sunday, September 25th

Excursions

Archaeological sites of interest in the area
Lunch on their own and afternoon in Sarlat
Visit to Rouffignac

Dinner restaurant "Le Font de Gaume"

Monday, September 26th

Final Presentations and Discussion

The Paleogeography of the African Middle Stone Age Project: An introduction to the GIS-based database, and preliminary results (*Marean and Lassite*)— 9:00-9:30
The Paleolithic of the Indian Sub-Continent (*Petraglia*) – 9:30-10:00.
An Archeological Database for the LGM in Italy (*Peresani and Mussi*)—10-10:30
Availability of Archeological Data in Eastern Eurasia (*Golovanova and Vishnyatsky*)—10:30-11:00

Revisiting Prospects and Problems in the Application of Eco-Cultural Modeling to Human Populations—11:00 –11:30

Linguistics and Cultural Anthropology

Correlation Between Ecology and Linguistic Diversity *(Coupé)*—11:30-12:00
Ethnicity and "Paleo-ethnicity" (*Hornborg*)—12:00-12:30

12:30-2:00 Lunch (Chez Jugie at Laugerie Haute). A bus will take participants to the restaurant.

Discussion: The Applicability of Eco-Cultural Niche Modeling to Cultural Variability and Population Dynamics Final Discussions

Strategies for Organizing and Funding New Interdisciplinary Research Initiatives—4:20-5:30

7:00 Final Dinner at the Auberge Veyret.
Nice restaurant with traditional French cuisine close to Les Eyzies. A bus will take the participants there.

Tuesday, September 27th

A bus will take the participants to the Bordeaux airport at 9:00 a.m

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Rationale of the symposium

One of the main objectives of the OMLL program of the European Science Foundation is to evaluate the size, degree of adaptation to environmental conditions, geography , and displacements of past human populations. Changes in the size of hominid groups have certainly played a role in the emergence and continuation of articulated language. They have conditioned, once this communication system has consolidated, mechanisms of language diversification and linguistic contact.

Establishing ways to evaluate the ability of past human populations and their subsistence strategies to cope with different environmental situations and adapt to climatic changes is crucial to assess hominid cognition, communication skills, and the level of dependence on environmental constraints of their technical systems. Identifying these strategies would have, for example, obvious implications for our understanding of Neanderthal adaptation and, perhaps, the factors that led to their extinction.

Identification of the geography of past culturally coherent human groups and its evolution through time is key to understanding the complex mechanisms that determine interactions among genetics, linguistics, cultural affiliation, and climate. Firm identification of such geography since the end of the Upper Palaeolithic would allow archaeologists, among others, to assess the pertinence of the Nostratic hypothesis.

Archaeologists frequently encounter difficulties in gathering this information, especially for remote periods due to: 1) taphonomic processes, 2) differential visibility of archeological remains and 3) intensity of surveys among regions. The occurrence of archaeological sites on the landscape is not representative of their original spread. Therefore, it is difficult to identify cultural territories, test their correspondence to linguistic/genetic boundaries, and evaluate relationships to the natural system (environment, climate).

This symposium seeks to explore the potential of Eco-cultural Niche Modelling softwares, such as GARP, CSM, and Physiology, as tools to predict the geography of past human populations and associated mammal/vegetal communities. These tools have already demonstrated their ability to model ecological niches of plant and animal species and predict their geographic distributions based on biotic and environmental data.

They may now be used to address *past human systems*, namely, archeological populations of hominids and humans in the Old and New World and their eco-cultural niches, *past natural systems*, namely, the geological, paleobiological and paleoenvironmental data, and propose informed hypotheses on the geographic spread, migration, and eco-cultural adaptation to biotic and abiotic environments by hominid and archeological human populations.

Should these predictive methods be considered viable, the second aim is to establish an interdisciplinary cooperation among archaeologists, paleoclimatologists, paleobiologists, informaticists, linguists and geneticists that can allow these scientific communities to work together to extend the successful program of biodiversity informatics to patterns and processes of cultural evolution and adaptation in changing environments.

This requires the identification of research areas of common or overlapping interest, inventory of existing databases relevant for the goals of the cooperation, discussion of protocols and timing for new data acquisition, and the identification of institutions, research teams, and individuals that can take responsibility in collaborative research programs.

The symposium also seeks to establish the computational parameters and algorithms in the modeling software that need to be extended to accommodate new data sets for eco-cultural niche modeling.

In sum the aims of this symposium are integral to the OMLL program and seek to expand the dialogue between the different scientific communities sharing an interest in OMLL topics.

Background

The organization of this symposium follows, and is seen as a necessary complement, of an exploratory workshop that took place on March 11-13, 2004, at the University of Kansas, Lawrence. This event was funded by the National Science Foundation and chaired by Drs Dixie West and Leonard Krishtalka, Biodiversity Research Center, University of Kansas (KU-BRC), co-PIs on the NSF grant that funded the workshop.

The 23 participants at this event represented a number of disciplinary domains, including: Old and New World archaeology, paleobiology, biodiversity science, climate and environmental systems, and computer science and informatics. With the exception of one scholar each from Europe, Israel and Mexico, all participants at the workshop represented US research institutions.

This workshop was devoted to: 1) establishing the state of knowledge with regard to eco-cultural niche modeling through presentations by selected workshop participants, 2) identifying the opportunities and constraints in accomplishing eco-cultural niche modeling, and 3) identifying the best demonstration projects for eco-cultural niche modeling and establishing a plan and timetable for accomplishing the project(s).

Participants recommended that proof-of-concept research in this area be launched as soon as possible because of the breakthrough science it promised for understanding the bio-cultural evolution of humans worldwide during the past 2 million years (see below). Integral to this overall recommendation was the determination that

- **Modeling regimes** demonstrated at the workshop (GARP, CSM, Physiology Model) could be expanded to either encompass cultural parameters or test current hypotheses of human adaptations. GARP and CSM, in particular, could accommodate the chronological and geospatial diversity of the archeological record. The Physiology Model could test hominid energetics and hypotheses of predator/prey interactions and changes in prey size over time.
- **Climate coverages** and modeling capabilities at NCAR and elsewhere could be harnessed to target specific archaeological sites and peoples in the New and Old World that are deemed most conducive to eco-cultural modeling.
- Archeologists can define **"Anthrocore",** a core set of parameters for quantifying eco-cultural niches for comparability and modeling, e.g., location, chronology, paleoenvironmental associations, technology.
- **Proof of concept:** three first projects, two in the Old World, one in the New World that utilize the most robust and readily available data sets from the archeological record:
  - **The Clovis Expansion**
  - **Neandertal/H. s. s. dynamics during the Middle and Upper Paleolithic**
  - **The *Homo erectus* expansion (Acheulean) across the Old World**
- **Organization of workshop,** probably in France,

On April 28, representatives of the Eco-Cultural Modeling working group presented the results of the March workshop to NSF program officers, who were enthusiastic about continued support for this project and requested that workshop participants submit a proposal for additional funding to hold a second, larger workshop in France.

How GARP works

A major recent advance in the study of natural systems has been the development of a biocomputational architecture for predictive modeling of complex biodiversity phenomena that were hitherto intractable. The research, funded by NSF, deploys a machine-learning genetic algorithm to model the ecological niches of plant and animal species and predict their geographic distributions based on biotic and environmental data (Peterson 2001; Chen and Peterson 2000). The machine-learning approach, called the Genetic Algorithm for Rule-set Prediction (GARP; Scachetti-Pereira 2002), has been applied successfully to topics as diverse as gap analysis (Peterson *et al.* 2002b; Peterson and Ortega-Huerta submitted), habitat conservation (Peterson *et al.* 2000; Chen and Peterson in press), climate change projections (Peterson *et al.* 2001, 2002d), predictions of species invasions (Peterson and Vieglais 2001), and predictions of the spread of emerging diseases (Peterson *et al.* 2002c).

GARP data include occurrence points for species of interest and landscape variables that characterize ecological and environmental dimensions that may or may not be involved in limiting the species' potential distribution. In GARP's machine-learning environment, species' occurrences are related to the landscape variables to develop a heterogeneous rule-set that defines the distribution of a species in ecological space (Costa *et al*. 2002), which can then be projected geographically to predict potential distributions (Peterson *et al.* 2002b). GARP accomplishes this task by relating ecological characteristics of species' geographic occurrences to ground observations randomly sampled from the study region. The result is a set of decision rules that best summarize factors associated with the species' presence, thereby constituting a model of that species' ecological niche (or, more properly, a partial niche model, as additional environmental dimensions could always be considered).

This niche model can be visualized as a potential geographic distribution via a spatial query to identify those areas on the landscape in which the modeled niche conditions are fulfilled. The model of predicted geographic distribution can be tested in the field, overlaid on geography to predict geographic occurrence and potential spread of a species under current and past conditions and different scenarios of change. There is good evidence that such ecological niches represent a constraint on species' distributions in a broad diversity of geographic and community contexts (Peterson and Vieglais 2001), and that they remain stable and conserved over even moderate periods of evolutionary time (Peterson *et al*. 2002b).

GARP has seen extensive improvement and testing in recent years, including detailed sensitivity analysis (Peterson and Cohoon 1999; Stockwell and Peterson 2002a, b; Anderson *et al*. 2002). Finally, a recently developed desktop version of GARP (Scachetti-Pereira 2002) offers a greatly improved user interface; in particular, many processes are automated that permit analysis and testing of different hypotheses: (1) jackknifing inclusion/exclusion of ecological/environmental data layers; (2) bootstrapping the inclusion of species' occurrence points; and (3) jackknifing inclusion/exclusion of predictive algorithms included within the genetic algorithm. The desktop version of GARP, developed at the KU-BRC, is now available for free, public download (http://beta.lifemapper.org/desktopgarp/).

Broader Impact

We believe that, if successful, this symposium will establish an interdisciplinary cooperation among archaeologists, paleoclimatologists, paleobiologists, informaticists, linguists and geneticists from Europe, the US and Russia that will allow these scientific communities to work together to identify the geographic extent of past human communities.

One of the grand challenges for the 21st century is understanding coupled natural and human systems and their reciprocal impacts. Such understanding requires: enabling access to data across biodiversity, ecology, earth systems science and the human-dimension; mining, analyzing and modeling these data for new knowledge; and apprising decision-makers and the public of the insights discovered. Research that exploits computer science and information technology to bridge natural and human systems will advance our ability to study aspects of biocomplexity across these systems.

The proposed workshop and follow-on projects constitute a proof-of-concept endeavor that will unite multiple disciplines and data domains in investigations of past coupled and natural systems. If successful, the project will create a new computational research community with a systems approach that includes components of the biotic, environmental, anthropological and information sciences—much as informatics has done for the biodiversity sciences. Success will also foster the education and training of the next generation of paleobiological and anthropological informaticists, and bring the results of knowledge networking of coupled natural and human systems to the public.

The foremost merit of the proposed workshop is the potential application of a professional level of informatics engineering and analysis to heterogeneous data and complex, large-scale research problems in prehistoric coupled natural and human systems that are currently not possible. The workshop will bring together a multidisciplinary and multisector intellectual team that unites the biotic, environmental, anthropological and information sciences to determine the feasibility and methods of extending a successful program of biodiversity informatics to patterns and processes of pre-human and human evolution and adaptation in changing environments.

References

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