The ethnoarchaeology of firewood management in the Fang villages of Equatorial Guinea, central Africa: Implications for the interpretation of wood fuel remains from archaeological sites

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A B S T R A C T
In archaeological literature, the study of trees and wood remains is a topic of relatively marginal interest, especially compared to texts on crops and human–animal relations. However, charcoal is the most frequent botanical remain found in archaeological sites. Charcoal analysis can therefore play a major role in the development of studies in both landscape and palaeoethnobotanical reconstruction. The majority of the archaeological charcoal assemblages reflect the exploitation of wood as an energy source (fuel). The archaeological study of firewood selection has been predominantly developed from “eco-utilitarian” or “subsistence economy” perspectives, but has not yet considered fuel collection and use as one of the most enduring categories of human–environment interactions, nor has archaeology looked into its potential as a source of empirical information on past perceptions of, and interactions with, ancient landscapes. The aim of this paper is to expand previous archaeological work on the interpretation of charcoal macro-remains through the study of firewood collection as a historically constituted, socially mediated and archaeologically observable landscape practice. In order to achieve this, we present an ethnoarchaeological case study from the Fang society of Equatorial Guinea (central Africa) aimed at gaining a better understanding of the complex interactions between cultural, ecological and economic variables in firewood collection strategies.

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Introduction: trees and firewood in archaeology

Following a long history of relevant research within anthropology, the archaeological study of trees and wood through their material remains retrieved from excavated sites remains a topic of relatively marginal theoretical interest. Compared to the diversity and thematic range of the literature dealing with animals and crops (cf. Ingold, 1988; O'Day et al., 2004; Palmer and Van der Veen, 2002) trees have received limited attention (Rival, 1998, p. 1). Waterlogged or charred remains of unworked wood have been extensively deployed in reconstructing ancient environments and human impact on the landscape (see edited volumes of the proceedings of the International Meeting of Anthracology: Damblon and Court-Picon, 2008; Fiorentino and Magri, 2008; Thiébault, 2002; Vernet, 1992). Trees and wood are, however, notably absent from broader debates on how the interactions of past societies with their environments were socially mediated. By contrast, issues of agricultural geographies, food procurement and processing, and culinary traditions predominate the relevant literature being both intensively theorized and methodologically explored topics (e.g., Bogaard, 2005; Boyd, 2002; Fairbairn, 2005; Van der Veen, 2005).

Archaeological wood macrofossil analysis, including the remains of waterlogged and carbonized wood, has a relatively short history in the field of archaeobotanical studies (see overview in Asouti and Austin, 2005). This paper focuses on a specific category of unworked wood remains, charcoal macrofossils originating in stratified archaeological deposits that represent the residues of domestic fuel consumption. The reason for this targeted focus is that domestic firewood remains represent the residues of purposeful human action (i.e., the intentional burning of wood as fuel) (Western, 1971). This critical property often cannot be ascertained for waterlogged plant macrofossils (i.e., unworked wood and other plant parts). Furthermore, firewood has been the principal source of energy for pre-modern societies worldwide, with a history of exploitation stretching as far back as the Lower Palaeolithic. In this sense, firewood collection constitutes one of the most enduring categories of routine landscape practices on par with food procurement and dwelling (Heizer, 1963). Therefore, its archaeological
study holds distinct potential for exploring in empirically informed ways ancient perceptions of, and interactions with, past landscapes.

Current epistemological contexts: charcoal analysis (anthracology)

Following a period of intense introspection and debate on its analytical potential and limitations (cf. Chabal, 1997; Chabal et al., 1999; Piqué, 1999; Smart and Hoffman, 1988; Vernet and Thiébaut, 1987) the analysis of ancient firewood macro-remains (the principal, if not exclusive, objective of the field of charcoal analysis/anthracology) has recently witnessed a resurgence of high-profile publications that have established internationally its position within archaeobotanical and palaeoecological research (e.g., Allué et al., 2009; Asouti, 2003a; Asouti and Austin, 2005; Asouti and Hather, 2001; Delhon et al., 2009; Emery-Barbier and Thiébaut, 2005; Figueiral and Mosbrugger, 2000; Heinz et al., 2004; Marguerie and Hunot, 2007; Théry-Parisot et al., 2010). In its current context, charcoal analysis has often been approached through what can be termed the “ecological-utilitarian” paradigm. This paradigm conceptualizes firewood collection primarily as a resource extraction mediated by the Principle of Least Effort (PLE: Shackleton and Prins, 1992). According to the PLE wood fuel is collected in direct proportion to the availability and ease of collection of tree and shrub species in past vegetation. Hence archaeozoological datasets can be considered, under certain sampling and analytical provisos, as a composite reflection of past vegetation and its fluctuations through time, whether climate- or human-induced (Chabal et al., 1999). More recent developments have expanded the remit of the PLE by drawing on the paradigm of “subsistence economy”. The principal aim has been to construct frameworks of reference predicting group perceptions (classified by the prevailing mode of production, i.e., hunter-gatherer, pastoralist and small-scale farmers, rather than ecological conditions) of the availability of fuel resources that might have influenced human interactions with woodland vegetation (Asouti and Austin, 2005). A related aim has been to identify the range and spatio-temporal patterning of economic behaviors to which firewood exploitation was integrated (e.g., lumbering, foddering, cultivation, hunting, pastoral production, etc) (Asouti and Austin, 2005).

While we consider all these perspectives as valid and informative, in this paper we argue that both the ecological-utilitarian and the subsistence economy paradigms can be substantially improved by moderating their dependence on predictive models drawn from environmental determinism and economic functionalism respectively. Our aim is to expand previous work, largely inspired by the PLE, by focusing on the description and interpretation of firewood collection strategies as historically constituted, socially meditated and, ultimately, archaeologically observable landscape practices. At the level of archaeological interpretation this can be achieved through the adoption of an explicit contextual approach which the archaeological record is, at least in theory, well-placed to accommodate. This involves the consideration of multiple lines of evidence other than charcoal, in order to reconstruct interactions with, perceptions of, and attitudes to past landscapes. In order to demonstrate the relevance of socio-cultural variables in the structure and organization of firewood collection strategies, we present a recent ethnoarchaeological case study from the Fang villages of Equatorial Guinea (Picornell, 2008, 2009). Drawing on this research, and intersecting it with other studies realized in different ecological and cultural contexts, we will attempt to demonstrate the validity of the following premises: (a) that ecological, socio-cultural and economic imperatives are inextricably linked in shaping habitual practices of firewood collection; therefore their arbitrary separation, even when done for heuristic purposes, may be counter-intuitive and potentially misleading too, and (b) that it is necessary to interpret the remains of domestic firewood consumption not only as independent datasets, subject to their own analytical requirements and limitations, but also as the material residues of past behaviors that were integrated to the area- and period-specific social, cultural, economic and ecological contexts that embodied them.

The ethnoarchaeological approach

It has been proposed in a number of recent publications that ethnoarchaeology constitutes an appropriate way to expand the range of hypotheses currently applied to the analysis of fuel remains from prehistoric sites, in order to move beyond the classic palaeoecological and palaeoeconomic interpretations (cf. Dufraisse et al., 2007; Henry et al., 2009; Picornell, 2009; Zapata et al., 2003). Ethnoarchaeological studies can provide useful insights into how different ways of perceiving the landscape may be translated into habitual woodland exploitation practices – e.g., through firewood management strategies (Dufraisse et al., 2007, p. 115). Such insights can be used as starting points for proposing alternative hypotheses for the interpretation of wood charcoal assemblages in tandem with a detailed consideration of their archaeological contexts (Zapata et al., 2003, p. 163).

The use of ethnographic analogy has a long and distinguished history in archaeological interpretation (David and Kramer, 2006, pp. 43–54). Archaeobotany and anthracology in particular are not exceptional in this regard (cf. Stevens, 2003; Théry-Parisot et al., 2010). However, most archaeobotanical applications have focused on the construction of predictive models considering subsistence to represent a more “conservative” aspect of human lifeways subject to environmental and biological imperatives (David and Kramer, 2006, p. 136). Broadening the ethnoarchaeological perspective may provide opportunities to challenge the uniformitarian assumptions inherent in such models, hence avoiding the pitfalls of unilinear and potentially ethnocentric archaeological interpretation (David, 1992, p. 352; González Ruibal, 2003, p. 12). A consideration of cultural ethnography may also assist in deepening our understanding of the complex linkages between human perceptions of landscape affordances (i.e., what landscape resources afford for the realization of human goals; Ingold, 2000) and firewood collection practices. Our objective in undertaking ethnoarchaeological research has been to gain a better understanding of the complex ways in which cultural, ecological and economic variables may interact in shaping an activity as important and as routine as firewood collection in the life of pre-modern (in the technological and economic sense) societies.

Ethnoarchaeological research: the Fang of Equatorial Guinea

Fieldwork was carried out by Picornell during his stay in the Monte Alen region of Equatorial Guinea between September 2007 and July 2008. Fieldwork techniques were those commonly used in anthropological research: participant observation and semi-structured interviews. Contrary to established practice in ethnobotanical fieldwork (cf. Albuquerque et al., 2006) questionnaires were not used for obtaining quantitative data on the botanical species collected as fuel. In addition, Picornell followed a strategy of open-ended interviews aimed at encouraging local participants to recount their own experiences and perceptions of daily routines associated with fuel collection and consumption. The aim was not to quantify fuel selection (e.g., by constructing ranking orders of preferred firewood species) but rather to explore the local habitual practices associated with fuel exploitation. A total of 23
interviews were conducted in the Fang villages of Moka, Ngong and Misergue (Fig. 1). Participation in, and observation of, the daily tasks of Fang women from different villages and households provided the opportunity to document in detail the multitude of routine activities that were directly or indirectly associated with firewood collection and consumption. Additionally, interviews were conducted with three different groups of informants (Table 1) for documenting a representative range of the local perceptions of firewood exploitation, which could be compared to the evidence collected through participant observation.

The study area

The Monte Alen region is located in the center of the Niefang Mountain Range of Equatorial Guinea, in central Africa (Fig. 1). This is an area with a low population density (2.3 p/km²) (Fa, 1991, p. 140) and is delimited by the villages of Niefang in the north-west and Evinayong in the south-east, which are connected by road to the city of Bata, the capital of the Continental Region of Equatorial Guinea. Monte Alen was declared a natural reserve by the Guinean Government in 1988, under the guidance of the European Union. This political measure had a major impact on the Fang hunting practices, by banning the hunting of species traditionally exploited by these communities. Development programs brought frozen meat to villages to make up for the hunting ban. On the other hand, slash and burn agricultural practices were not considered to be detrimental to nature conservation policies, due to overall low population density in the protected area; thus no limitations or changes of customary practice were imposed, according to the individuals interviewed. In the Monte Alen area, Picornell worked primarily in the villages of Moka, Ngong and Misergue (Fig. 1). Moka and Ngong are located on the road which connects Niefang with Evinayong, at the eastern border of the protected area, while Misergue is situated in the south of the Monte Alen reserve. Moka and Ngong have an estimated population of 100 and 350 inhabitants respectively. Both communities belong to the Esaon and Nzomo clans. Misergue is the smallest of the three villages, with less than 100 inhabitants, all identifying themselves with the Anvom and Ntum clans.

The prevailing climate is hot and humid, although it is tempered by the proximity of the Monte Alen area to the Niefang mountain range. Annual precipitation is 3528 mm, with an average temperature of 20.5 °C (Sabater-Pi, 1981). Local vegetation consists primarily of the typical African Guineo-Congolian rainforest dominated by trees and large shrubs such as Pterocarpus soyauxii, Teighemella africana, Brachystegia mildbraedii, Canarium velutinum, Erythrophleum ivorense, Uapaca guineensis, Dacryodes buettneri and Parkia bicolor (Sayer et al., 1992). Secondary vegetation is encountered in fallow orchards (Fa, 1991, p. 31–47). During the first year after the abandonment of an orchard, land is colonized by tall herbs of the genus Aframomum. Following that, pioneer shrub and small tree species (Musanga cecropioide, Trema orientalis, Fagara macrophylla, Vernonia conferta and Alchornea cordifolia) spread. After 3–4 years mature secondary forest develops with a dense and mostly

Fig. 1. Map of Equatorial Guinea, showing its position in the African continent.
impenetrable undergrowth consisting of herbs (*Halopegia azurea, Sarcocephrynum velutinum, Haumania dancikelmaniana*), climbing palms (*Onoccynamus manni, Lacsocperma acatiflorum*), lianas (*Cissus lamprophyla*) and cryptogam epiphytes. Trees in these secondary forests comprise tall and slow growing species such as *Pyramanthus angolensis, Terminalia superbba, Aucoumea klaineana, Chlorophora excelsa* and *Caloncoba welwitschii*. Local fauna is enormously diverse. Typical species include the western lowland gorilla (*Gorilla gorilla*), chimpanzees (*Pan troglodytes*) and black colobus monkeys (*Colobus satanus*) ([Garcia and Mba, 1997]), as well as the forest elephant (*Loxodonta africana*), leopards (*Panthera pardus*), buffalos (*Syncerus caffer*), giant pangolins (*Smutsia gigantea*) and the grey necked picathartes (*Picathartes oreas*) ([Rist, 2007, p. 16]).

The Fang landscape: settlement patterns and subsistence activities

The Fang, like other slash-and-burn societies in tropical environments, maintain a topocentric organization of space ([Descolé, 1988, p. 156]). The village (dzáa) occupies the center of social space (Fig. 2) from which departs a network of paths that connect the village with other areas of habitual activities, such as the orchards (cultivation) or the rivers (fishing). The forest (afán) is perceived as a space inhabited by the spirits of plants, animals and the ancestors, which are seen as an integral part of the social life of the village. Roads, pathways, orchards (tsií) and fallow land (ekot/mbut, see differences below) are perceived as a frontier zone between the center of Fang social life (dzáa) and the forest (afán).

Rights of land use are divided amongst individual households. There are no artificial physical boundaries (e.g., fences) demarcating household property. Instead, the inhabitants of each village as well as those of neighboring villages recognize as boundaries natural elements such as individual trees, rivers or hills. Although every household has use rights over the plots on which its orchards are planted, no property rights over the land itself are recognized; instead, formal ownership of the land rests with the community. However, individual households maintain exclusive rights over the exploitation of resources (wild fruits, trapped animals, etc.) located in orchards as well as fallow land previously cultivated by the household, even though new orchards may not be planted again in the same locations.

The Fang practice a diversified economy organized in seasonal cycles (Table 2) by intervening intermittently in different ecological niches, a practice that contributes to the overall maintenance of local biodiversity ([Carrière, 2003, p. 98]). With the start of the rain season the men of each household clear the land for planting new orchards. Orchards may be established both in the rainforest and in the secondary forest. Not all vegetation is cleared. Some trees are spared because they have a very hard and difficult to cut wood, they produce desirable fruits, for their shade, or due to perceived undesirable properties. An example of the latter is *eluk* (*Alstonia congensis*). Its bark has a bitter taste that the Fang believe can be transferred to planted crops. The preservation of such trees, collectively named *ntolog abok* (*orphan trees*), assists forest regeneration when the orchards are left fallow, due to attracting forest birds that disperse the seeds of tree and shrub species ([Carrière, 2003, p. 200]). This ecological process is responsible for the development of secondary forests containing plant biodiversity hotspots ([Carrière, 2003, p. 190; Descolé, 1988, p. 80]). Cleared vegetation is left to dry

<table>
<thead>
<tr>
<th>Table 1</th>
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<tbody>
<tr>
<td>Informant</td>
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<tr>
<td>Individual interviews with adult women who agreed for Picornell to join them in their daily activities</td>
</tr>
<tr>
<td>Group interviews with the men of each village</td>
</tr>
<tr>
<td>Knowledgeable individuals who were identified as such by the rest of the community, and could recall and dispense information on local traditions, and the meanings and perceptions of plants and forests and how these changed through time</td>
</tr>
</tbody>
</table>

where she will cook for the family. Kitchens are often used by several adult females (e.g., a wife, an adult unmarried daughter, a widowed sister or an unmarried niece) and for this reason may contain several hearths (for more details on Fang villages and households see *Carrière, 2003*, pp. 27–118; *Picornell, 2009*, pp. 138–141).

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| Fig. 2. Scheme of the Fang topocentric organization of the space, in which the village (dzáa), the center of the social activity, is separated from the primary forest (afán) by other social spaces (orchards, tsií, and fallow lands, ekot/mbut). |  |  |  |
for a few days and it is burnt afterwards. In this way all small branches and leaves are removed, thus facilitating the removal of tree trunks and larger branches. The Fang believe that the ashes produced by vegetation burning enhance soil fertility. Soil regeneration is the most critical factor for the maintenance of sustainable orchard plantations in the long term, since new orchards are planted every year. For this reason when an orchard becomes unproductive the Fang will leave it fallow for at least 6–8 years, in order to ensure proper vegetation and soil regeneration. Fallow lands (ekot) develop secondary vegetation and with time mature secondary forests (mbut).

Following clearance and burning, the responsibilities of the male members of the household with regard to field preparation are terminated. Henceforth orchards become essentially female spaces. The first thing that women do is to remove all the trunks and branches which have escaped fire. They collect all the dry wood and stack it on piles at the borders of the orchards. Then they and branches which have escaped fire. They collect all the dry spaces. The first thing that women do is to remove all the trunks and branches. Men also provide wood for emergency fuel supplies with the female members of other households.

Table 2

<table>
<thead>
<tr>
<th>Name of the season</th>
<th>ESEP</th>
<th>OYÓN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Months</td>
<td>NKOT (dry season)</td>
<td>SUCÚ (rainy season)</td>
</tr>
<tr>
<td>December, January, February</td>
<td>Dry season, with some occasional rains during the night</td>
<td>Dry season, with tropical storms in the afternoon</td>
</tr>
<tr>
<td>Climate</td>
<td>– Tending of the orchards (women)</td>
<td>– Tending of the orchards (women)</td>
</tr>
<tr>
<td>Subsistence activities</td>
<td>– Planting of crops (women)</td>
<td>– Planting of crops (women)</td>
</tr>
<tr>
<td>– River fishing (men, women and children)</td>
<td>– River fishing (men, women and children)</td>
<td>– River fishing (men, women and children)</td>
</tr>
</tbody>
</table>

Firewood management practices

Firewood collection

The firewood used by Fang households is a by-product of land clearance and field preparation. Women remove all trunks and branches with diameter >5–8 cm and pile them on the field edges. This supply of wood is the main source of domestic firewood until the next clearance cycle. Women collect and transport firewood back to the village during their daily visits to the orchards to tend the crops and/or harvest the daily food supply. Fuel, like food, is not stored. Correspondingly there are no woodsheds in the Fang houses. Women keep the firewood they use for cooking on the day near their kitchen fireplaces, and replenish this supply upon their next trip to the orchards.

When there is a sporadic rise in firewood demand for special events (e.g., funerals or traditional naming celebrations) women collect larger quantities of wood in order to cook for the household and its guests. This is done gradually, starting a few days before the event during routine trips to the orchards. A staple of such feasts are the fermented wrapped manioc sticks. They consist of tubers that are fermented for 3 or 4 days in specially prepared spaces on the riverbanks and are then crushed, wrapped in leaves of okiéñ (Megafrinium macrostachium) or embió (Marantocloa phillipes) and boiled for at least 1 h, which requires large quantities of firewood by comparison to normal daily fuel consumption. If the supply of firewood from the orchards is not sufficient to cover fuel demand for such events, women may cut down a young tree from an ekot plot (fallow land) belonging to their family. This is left to dry for a few days before it is split in smaller logs and transported back to the village. This is the only time when women may make a trip dedicated to firewood collection. Moreover such trips are only made to the ekot. Firewood is thus always collected from socialized spaces (orchards, fallow land), never from the afán (Table 3). Women are also not allowed to collect firewood from the orchards and the ekot plots managed by other households. In the event of extraordinary fuel shortages, women must negotiate obtaining emergency fuel supplies with the female members of other households, in exchange for some sort of compensation (food, labor, etc.).

The toolkit used for wood collection consists of axes, machetes and baskets (nkueñ). Axes are only used by men for cutting down trees. By contrast, machetes are used by women to split the trunks and lop the branches that are collected from the orchards following clearance and burning. The nkueñ is a cylindrical basket carried only by women. It is made from vegetal fiber from lianas (Onococalamus, Calamus, Anristolphia, Eremospatha) and is used to transport crops, gathered plants and firewood.

Men may occasionally gather firewood for specific purposes (Table 3). Adult men may cook game which is forbidden to women especially medicinal plants, vegetal fibers for basketry and wild fruits. Although river fishing is practiced by both men and women, hunting by trapping is an exclusively male activity (Rist et al., 2007).

Table 3

The organization of firewood collection, use and discard of fire debris according to gender (adult men and adult women) and firewood collection catchments.

<table>
<thead>
<tr>
<th>Collection area</th>
<th>Agent</th>
<th>Toolkit</th>
<th>Consumption space</th>
<th>Use</th>
<th>Deposition of fire debris</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tsií (orchards)</td>
<td>Adult women</td>
<td>Machete, nkueñ</td>
<td>Kitchen (female space)</td>
<td>Daily food preparation and other domestic purposes</td>
<td>Deposited in the skin (specific manure production place behind kitchens)</td>
</tr>
<tr>
<td>Ekoítk Mbut Ancient fallow orchards</td>
<td>Adult men</td>
<td>Machete, nkueñ</td>
<td>Kitchen (female space)</td>
<td>Special food preparation for social events (feasts)</td>
<td>Deposited in the skin (specific manure production place behind kitchens)</td>
</tr>
<tr>
<td>Ekoítk Mbut Ancient fallow orchards</td>
<td>Adult men</td>
<td>Machete, nkueñ, Axe, machete</td>
<td>Abí (male space for communal gatherings)</td>
<td>Preparation of food forbidden for women and children</td>
<td>Scattered indiscriminately away from the abí</td>
</tr>
</tbody>
</table>
and children, following cultural taboos that depend on clan membership, or they may prepare medicinal brews specifically destined for men. Such cooking is done over a simple hearth set in the abá, a rectangular edifice used for hosting men's meetings which is traditionally out of bounds for women. Firewood used for such events is collected by men in the ekot of their family or on the borders of the roads and paths that link the village with their hunting grounds and the rivers. On such occasions men cut down young trees that are left to dry by the roadside. Once dry, wood is transported back to the village as whole trunks (i.e., without splitting) since men do not use nkueiñ baskets which are considered the exclusive property of women.

**Firewood consumption**

The bulk of the firewood collected from the orchards is used for cooking. The structure of the kitchen hearths is simple: wood logs and branches lay directly on the kitchen floor and cooking pots are placed atop three stones. Women start the cooking fires in the morning of each day using two kinds of tinder: dry reeds of *Afromamum giganteum* and dry palm fruit fiber (*alén – Elais guineensis* and *dzang – Raphia hookeri*) produced from the crushing of palm fruits for oil extraction. Fires remain lit for the most of the day, since they are used for multiple purposes: cooking, boiling the fermented manioc sticks, heating water, smoking foodstuffs, preparation of medicinal brews, and keeping mosquitoes away with their smoke. When women leave the kitchen to work in the orchards or fish in the river, they pull the logs away from the fireplace in order to prevent them from burning during their absence. The hearths located in the abá are also simple structures. Each abá has a single hearth located at the center of the edifice. Besides preparing food and brews consumed by men, it is also used, albeit for shorter periods of time compared to kitchen hearths, for heating during men's meetings at daybreak or during the night.

**The discard of fuel debris**

One of the first tasks undertaken by women each morning is sweeping kitchen floors. During the day the organic waste generated by food processing and other activities is left on the kitchen floor to be removed next morning. Charcoals (*mviri*) and ashes (*asup*) from the hearths are also removed every morning, although they are not re-used as has been documented for other African societies (cf. Zapata et al., 2003, pp. 171–172). Instead all fuel debris is discarded in the akun together with the rest of the organic waste swept from the kitchen floors. The akun is a space behind the kitchen building, fenced by banana trees, dedicated to the composting of organic waste in order to produce manure for the orchards. Fuel debris from the abá hearths is discarded randomly behind the edifices without any spatial restrictions. It is important to note here that the volume of fire debris generated in the abá hearths is considerably smaller when compared to that of the kitchen hearths that are almost continuously used throughout the day.

**Cultural aspects of firewood management**

Wood is abundant in the local vegetation and the Fang consider it as the best fuel. No other sources of energy were recorded to be in use during Picornell's fieldwork. The Fang have a shared notion of what constitutes “good fuel”: dry logs with diameter between 5–8 cm and 15–20 cm. Firewood collected from the orchards fulfills these requirements since trees are cut, left to dry, burnt in order to remove foliage and smaller branches, and their trunks are split into smaller logs. Log diameter is an important factor in fuel selection because logs will burn slower and for longer periods of time (which suits the Fang requirements for cooking, smoking and other purposes) compared to thinner branches and twig wood. As it has been noted by other ethnoarchaeological studies (cf. Dufraisse et al., 2007, p. 121; Zapata et al., 2003, p. 173) botanical species *per se* does not constitute a criterion in firewood selection. When the Fang use wood as raw material, for manufacturing or timber, they tend to select species that are recognized as more appropriate for these purposes. By contrast, when they collect firewood they do so indiscriminately, the most important criteria being log diameter and ease of collection rather than botanical species. Yet, this does not preclude all consideration of species in relation to local perceptions of firewood classification. Fang men and women commonly perceive as “good fuels” dense and hard woods that burn slowly and do not produce too much smoke. In relation to this concept, there are “ideal” firewood species and others that are considered as low quality fuels. During interviews Picornell documented 16 species that were considered by more than three individuals as “appropriate firewood” (Table 4). It is interesting, however, that this concept of “good fuel” remains inoperative when it comes to the routine provisioning of the household energy needs. The only instance in which it becomes applicable is when women face shortages in the fuel regularly supplied from field clearance and must, as a result, undertake extra trips to cut small trees in the ekot (fallow land). In this case, they will be selective in their choice of species. In addition to this, there are other species that are gener-

### Table 4

<table>
<thead>
<tr>
<th>Botanical species used as fuel documented during fieldwork</th>
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ally considered as “bad fuels” (Table 4). Sene (Albizia adianthifolia) and olong (Zanthoxylum heitzi) are not normally used as firewood in the kitchen and the abá hearths alike, because they produce too much smoke. Nevertheless, all interviewees agreed that they would rather use sene and olong firewood from the orchards belonging to their families instead of taking the extra effort of cutting trees in the eket.

In addition to this, there are socially forbidden species which are never used as firewood in the village fireplaces, even if they have been cut down during field clearance. These are ebañ (Pentaclethra macrophylla) and ñuará (Tetrodorchidum didymostenon) (see also Table 4). The reason for their avoidance has to do with Fang perceptions of nature and the categorization of plants. The Fang, like other slash-and-burn societies inhabiting tropical rainforests (cf. Descôl, 1988; Fons, 2004; Mallart, 2008; Viveiros de Castro, 1996) do not perceive nature as a separate entity from the human sphere. Places, plants and animals are believed to be imbued with spirits that constitute social entities, able to interact with people. Both human and non-human elements of the environment have a double nature: a tangible, visible one and another which is invisible and belongs to the domain of the spirits (Ngema-Obam, 1983). In this sense, plants, animals and ancestors are perceived as live agents with whom the Fang interact in the course of their daily life. Ebañ and ñuará represent such entities, which furthermore people must keep away from the village. Ebañ is a big tree with large ligneous pods containing large seeds. Its name derives from the onomatopoeia of the noise produced by its pods when they burst open as seeds mature. This noise frightens people when they hear it in the forest and the tree is thus known as the “one who suddenly shoots the crossbow in the middle of the forest” (Mallart, 2008, p. 980). As a result, ebañ is considered to possess a very violent spirit and the Fang believe that if they bring it into the village to burn in their fireplaces, it will be the cause of violent quarrels between household members and the community. The name ñuará derives from the verb ñuaráñ, which means “to rot”, “to decay”. The Fang thus believe that if somebody burns this wood the wealth and richness of his/her family will decay. The ñuará will adversely affect the fertility of the orchards and even the fertility of the women of the household. It can also be used malevolently, to bring about such negative effects to other individuals by hiding a piece of cloth taken by a person in its trunk or even by naming a ñuará tree after this person.

Discussion

The question of which criteria determine fuel selection has been widely debated in the literature. It has been argued, for example, that firewood collection is always “selective” being linked to notions of preferred species (i.e., what constitutes “good fuel!”) and thus that the species composition of archaeological charcoal assemblages is likely to reflect such cultural filters (Piqé, 1999; Smart and Hoffman, 1988). Similarly, analyses focusing on the investigation of human impacts on past vegetation have usually associated fuel ranking systems with changes in sample composition. Thus assumed “preferred” fuel species (e.g., dense and slow burning taxa) are thought to be substituted in the medium to long term by species with lower density and heat value, spiny or difficult to collect taxa, and/or agricultural residues (e.g., animal dung) in response to the depletion of preferred wood fuels due to their over-exploitation (Miller and Smart, 1984; Miller, 1985). The finds of our ethnarchaeological research amongst the Fang query the expectations of such models, which may be based on a very selective reading of the ethnographic literature (e.g., Smart and Hoffman, 1988) or implicitly assume the separation of firewood collection from other subsistence activities and its operation primarily as “resource extraction” with progressively adverse impacts upon vegetation resources (e.g., Miller, 1985).

The Fang case study suggests that firewood choice sensu stricto is not conditioned primarily by species but focuses, instead, on the physical properties of wood (moisture content, size, diameter). This find agrees with previous research in wood fuel properties across different cultural and ecological contexts (Dufraisse et al., 2007; Johannessen and Hastorf, 1990; Théry-Parisot, 2002; Zapata et al., 2003). In this sense, it is very interesting that while “good fuel” criteria exist, their impact on actual fuel classification is manifested only when extra labor investment in firewood gathering is anticipated in order to provide justification for extraordinary, non-routine tasks (i.e., an extra trip with the sole purpose of collecting fuel wood, or the cutting down of one or more trees to be converted into firewood). On the other hand, even if there does not appear to be a selective criterion (“good fuel”) operating in routine daily firewood collection, there seems to be a restrictive one: socially forbidden species (ebañ, ñuará) are never used as fuel in Fang villages. This is directly related to cultural perceptions of the environment and systems of ethnobotanical classification and not strictly with chemical and physical properties of the wood of each species. The Fang collect as firewood all the residues of field clearance except for those that are subject to social restrictions. Similarly, restrictive criteria are applicable to the choice of catchment areas: firewood is always obtained from trees growing in socialized spaces (tsil, eket, mbut) never from the rainforest (afjín) where the spirits of plants, animals and the ancestors dwell. Generally, socially forbidden fuel species may be designated either for their perceived negative properties or for positive (i.e., desirable) ones such as their fruits and shade. Such issues, especially the question of the social inaccessibility of particular vegetation catchments, are predictably difficult to disentangle when it comes to archaeological charcoal assemblages. The broader patterns of species representation (e.g., expected occurrence and frequency of wood species in reconstructed vegetation units plotted against their occurrence in archaeological charcoal samples) and, where applicable, archaeological contexts (e.g., evidence for symbolically or ritually structured behaviors, and/or written sources) may offer useful starting points for considering the operation of restrictive criteria in prehistoric fuel selection.

One might object that such behavioral patterns are unlikely to be generally applicable as they are likely to occur principally in ecological and socio-economic contexts characterized by net wood “abundance” (e.g., closed canopy forests, slash-and-burn shifting cultivation systems, both applicable to the Fang case study). The key question is how to realistically measure wood “abundance”. Archaeobotanical and ethnographic models ranking individual species based on combustion properties may overlook other vegetation-scale properties such as ease of firewood collection and transportation. There is for example an extensive bibliography especially for small-scale, subsistence farming societies suggesting that the preferential collection of dry deadwood is commonly tested across different cultures and ecological contexts, ranging from temperate woodlands and tropical forests to semiarid savannas and park woodlands; no studies have indicated that live trees (even of taxa identified as “preferred fuels”) are cut for the purpose of fuel provisioning (bibliography surveyed in Asouti and Austin, 2005). Deadwood (standing or uprooted dead trees, fallen trunks and stumps, rotting roots, decaying hollow trees, shed branches and small round wood) is always found in woodlands due to environmental disturbances continuously creating and renewing its supplies. Furthermore, several studies have indicated that even in low density habitats (e.g., savannas or park woodlands) in arid and semiarid regions year to year deadwood productivity is remarkably stable, because it is primarily determined by factors (e.g., wind and browser damage, fungal and insect attacks, weather
impacts) other than those affecting the productivity of living plants (e.g., mean annual rainfall); in turn, stable deadwood productivity suggests that fuel supplies and harvesting patterns can be predicted and thus managed (Shackleton, 1998). Rates of fuel extraction will depend on the technologies used: hand-collection removes substantially less wood (by leaving behind large trunks and very small pieces) compared to mechanized collection (saws, machinery) that may result in quick depletion of the available supplies (Shackleton, 1998).

Research by Asouti (2003b, 2005, in press, forthcoming) and other authors (see reviews in Asouti and Austin, 2005; Marguerie and Hunot, 2007) has indicated that deadwood is ubiquitous in prehistoric charcoal assemblages. Although ascertaining the cause and degree of decay is not always straightforward when analyzing partially preserved charred wood fragments, their regular presence at the very least suggests that old-growth and/or persistent (i.e., long-lived) woodland habitats were available and harvested for fuel by prehistoric communities. Especially for the Near East and the Balkans, where there is no pollen or sedimentological evidence for woodland clearance and deforestation pre-dating the Early Bronze Age, it is very plausible that fuel, timber and fodder/graze procurement was managed in sustainable ways (cf. Asouti, in press; Willis, 1995; Willis and Bennet, 1994). Charcoal analysis from the Neolithic tell site of Çatalhöyük in central Anatolia has demonstrated that even in this case of a substantial community that was settled in the same location for ~1000 years and practiced mixed agro-pastoral production, there is no evidence for the depletion of “preferred fuels” through time, while dung also appears to have been used as a complementary source of fuel (perhaps seasonally) rather than as a substitute for wood (Asouti, 2005, in press, forthcoming; Asouti and Austin, 2005). The management of dry deadwood most likely played a major role in the long-term sustainability of fuel collection strategies (Asouti, 2005).

Our ethnographic case study indicates that perceptions of firewood availability are conditioned primarily by their economic context and associated subsistence strategies, to which the habitual collection of fuel for supplying of household energy needs is fully integrated. Fang firewood is the by-product of field clearance and preparation, while its collection and transport back to the settlement, and its consumption in domestic fireplaces, occur in tandem with routine food provisioning and cooking tasks. This observation is in general agreement with ethnographic and anthropological research on the fuel management strategies practiced by subsistence farming communities in other world regions as well (discussed more extensively by Asouti and Austin, 2005). It is possible therefore to outline with some degree of reliability key features of firewood collection practices: (a) the integration of fuel collection routines to the full spectrum of subsistence activities including foddering, gathering and timber provisioning, (b) the medium-to-long-term curation of vegetation resources through recycling (e.g., of defunct timber and wooden implements), and (c) the use of complementary energy sources, such as dry deadwood and dung, as fuel (Asouti and Austin, 2005). The co-evaluation of high-resolution charcoal data with other categories of archaeological evidence (architecture, hearth structure and function, seed archaeobotany, animal bone, soil micromorphology, population size) has assisted in determining the applicability of these principles in the case of Çatalhöyük (Asouti, 2005). Furthermore, ecological, ethnographic and anthropological research in different world regions has indicated that it is primarily the disruption of the prevailing economic strategies by socio-political and attendant ecological change, rather than climate- or human-induced fluctuations in the net availability of wood species, that may bring about major shifts in land use, including woodland exploitation (cf. Al-Bakri et al., 2001; Ali and Benjamin sen, 2004; Becker, 2001; Briscoe, 1979; Ellis, 2000; Reid et al., 2000; Sahel et al., 2008; Schweik et al., 1997). The conclusions of such studies converge in suggesting that firewood shortages emerge and eventually become irreversible once the energy demands of specialized craft industries need to be accommodated (e.g., metalworking), secondary products economies develop (e.g., arboriculture, expansion of pastoral production leading to vegetation clearance for the establishment of orchards and overgrazing respectively), market dependencies evolve and ownership of, and access to, the land and its resources is restricted by centralized systems of political and administrative control (Asouti and Fuller, 2008; Asouti, in press). In turn, such considerations should be built into anthropological research, with the aim to elucidate the degree to which fluctuations in the composition of charcoal assemblages may correlate with shifts in socioeconomic practices. If such correlations can be established, it is possible that changes in charcoal sample composition may reflect a re-orientation of firewood management strategies and goals, and their complex landscape interactions with other economic activities (e.g., craft and pastoral production) rather than the progressively adverse, unidirectional human impact on past vegetation due to wood fuel collection per se.

Conclusions

Prevailing theoretical models in the field of charcoal analysis such as the Principle of Least Effort (PLE) predict that in environments with abundant woody vegetation human groups will collect dry wood of particular species in accordance with their desirability as fuel, while selective criteria decline in importance in environments of low wood availability when fuel collection may become more indiscriminate (Shackleton and Prins, 1992). The Fang case study suggests that the classic PLE model can be expanded further by incorporating firewood management to the analysis of the broader economic strategies pursued by a given community. Perceptions of fuel scarcity amongst the Fang are not determined by net wood species availability in the local vegetation. Instead, they are integrally linked to the cycles of clearance and regeneration of secondary vegetation in cultivated land (orchards). Furthermore, criteria based on perceptions of “good fuel” are applicable only when the extra effort (translated into dedicated fuel collection trips) and labor (cutting down trees for fuel outside the clearance cycle) need to be justified as a response to shortages in the fuel supplies (vegetation clearance by-products) routinely exploited by each household. Finally, it should be stressed that no fuel collection occurs in vegetation catchments (i.e., the rainforest) that lay outside the socio-economic and cultural milieu of the villages.

In light of these observations, which are compatible with ecological, ethnographic and anthropological studies of fuel management practices in other world regions, we believe that it is necessary to re-direct the focus of the interpretation of archaeological charcoal assemblages away from strictly defined notions of “preferred fuel” species availability. This in itself is not a novel observation as it has been previously observed that it is the form and moisture content of the wood rather than botanical species that determine availability (Théry-Parisot et al., 2010). What is novel is the proposition, expanding on previous work by us and other scholars in the field of anthracology, that firewood collection forms an integral part of the social and economic life of pre-modern (in the economic sense of the term) societies. Therefore, just as it happens with other activities situated in the socio-economic sphere, it is governed by a broad spectrum of socio-cultural considerations that are not necessarily conditioned by species properties and their net availability and actual proportions in woodland vegetation (Asouti, in press, forthcoming; Asouti and Austin, 2005; Becker, 2001; Beauclair et al., 2009; Peluso, 1996). In relation to this, we suggest that other PLE-inspired models used to predict patterns
of firewood selection and management drawing on the principles of behavioral ecology (relating resource availability, use value and handling costs sensu stricto; cf. Marston, 2009; Rubiales et al., 2011) could also be improved through the consideration of culture-sensitive ethnographic studies and by building in socio-economic variables. Notions of “optimal behavior” in habitual practices of fuel collection and consumption must compute additional variables besides energy output, species availability, distance from habitation sites and floristic composition of vegetation units, if they are to produce realistic scenarios that can be credibly tested against the archaeological record of specific regions and time periods reflecting particular socio-economic, cultural and ecological contexts. Relevant variables include population size, wood extraction technologies, economic organization and change through time, socio-cultural factors, risk avoidance, compatibility with other economic and subsistence tasks, seasonality, and fuel storage or the lack thereof. It becomes evident therefore that, in practical terms, such an approach cannot be limited to the analysis of charcoal data in isolation, but must also involve an evaluation of multiple sources of evidence including seed archaeobotany, zooarchaeology, soil micromorphology, wood harvesting technologies, hearth structure and properties plus settlement structure/organization, and symbolic and ritual behaviors, if the aim is to achieve data-informed, realistic interpretations of prehistoric firewood management practices and landscape perceptions in their local and regional contexts.

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