DISCUSSION

STUDYING CHANGE

An initial aim of this project is to examine the reorganisation of social systems in the context of climatic and environmental change. This aim was frequently approached in archaeological analyses (Weiss/Bradley 2001; Haug et al. 2003; Tainter 2008, 44-45; Bettinger/Richerson/Boyd 2009; Langlais 2011; Bradtmöller et al. 2012) but fragmented data often permitted different, occasionally contrasting interpretations.

For example, in the Late Pleistocene, the transformation from the Late Magdalenian to the Azilian, the so-called Azilianisation, was regularly the subject of conflicting assumptions: The reflections of the abbot Henri Breuil about the French late Upper Palaeolithic record resulted in the statement: »Revolution, the Azilian is one«[53] (Breuil 1913, 216). Based mainly on the same record, Denise de Sonneville-Bordes came to the contrasting conclusion that the replacement of the Magdalenian by the Azilian was a progressive passage (Sonneville-Bordes 1966). These two different interpretations reflect different perceptions of historical developments as either revolutionary or evolutionary processes. The two types differ in tempo and mode in which variations appear: In a revolution, variations occur in a quick, step-wise transition, whereas slow, gradual transformations are considered as evolutionary processes (see Introduction, p. 1-5).

Contrasting perceptions of the process of change were also a subject in biology focusing on the presence of major revolutionary processes in a generally gradual process of evolution (Simpson 1944; Eldredge/Gould 1972; Eldredge et al. 2005). As important factors of identifying and defining these revolutionary periods were named: temporal resolution of the record and taxonomic level on which the research was focused (Thomson 1992). In ecology, different tempos were suggested to be influenced by the different levels of complex adaptive systems and these different tempos drove adaptive cycles but also sustained the complete social-ecological system in making it resilient (Holling 2001; Holling/Gunderson 2002).

Regarded as another social-ecological system, human behaviour should also be studied with varying focus of research to be able to study change. For example, changes in individual behaviour appear constantly (cf. Eerkens 2000; Eerkens/Lipo 2005) and small groups can adapt quickly to short-term local changes such as emigrating from areas affected by volcanic eruptions but return to these areas as soon as the surrounding appears again habitable (cf. Grattan 2006). Besides transformation in a behaviour, also appearance and disappearance can, hence, provide meaningful observations. Nevertheless, a common behavioural repertoire such as expressed for example by Magdalenian art was observed in the archaeological record over several millenia. Consequently, comparable to social-ecological systems, slow and fast processes also occur in human behaviour.

Nevertheless, the time frame has to be chosen deliberately. For example, a study of the period shortly before and after the above exemplified eruption would result in the detection of a significant change in the human behaviour (presence, then absence). In contrast, a prolonged time frame after the eruption would make the observation possible that the emigrants return. Comparably, constant but small variations in knapping techniques result in a long-term change (Hamilton/Buchanan 2009) that is only observable in a sufficiently long time frame. Moreover, these examples lead to another important question: What is perceived as change?

53 Translated by the present author. The original reads: »Révolution, L'Azilien en est une«.

A comprehensive answer cannot be provided by this study and for an often used »end of civilisation« scenario to raise awareness of the finality of civilisation, including the one's own, the Lateglacial record appears not to be a good analogy. To quote a popular song: »It's the end of the world as we know it« (R. E. M. 1987, Document) but life went on. The established FMG behavior of the Lateglacial Interstadial was not the end of behavioural development nor was the Late Magdalenian a beginning of this development. This study comprises only a short extract of human behavioural history assumed to encompass a single adaptive cycle of a social system.

However, the example of different perceptions of this process in the archaeological record from southwestern France helps to provide an interesting point to an answer to the above posed question: The dataset of Denise de Sonneville-Bordes was more fine-grained than that of abbot Breuil. Moreover, his previously mentioned quote continues: »No more figurative animals in art, only paintings on pebbles and walls with geometric or schematic elements. Revolution in the work of bone and deer antler«[54] (Breuil 1913, 216f.). Art can be regarded as a communicative expression and to be able to understand the content correctly, transmission of information is necessary, in particular, when abstraction is involved such as in schematic and geometric signs or letters of the alphabet. Thus, Breuil based his interpretation on a change in the social transmission of information. In contrast, Denise de Sonneville-Bordes based her considerations mainly on statistical variations of the lithic inventories and regarded the typology of organic barbed points also as evidence for the gradual development of the Azilian from the Magdalenian (Sonneville-Bordes 1966). Her analysis became possible by the greater focus on details. Moreover, this focus was set on variations in the individual manufacturing of equipment and the use of this equipment at various sites. As a result, the contrasting perceptions can be explained by different resolutions and a focus on different levels of human groups. These differences revealed fast processes in smaller groups and slow ones in larger entities. Apparently, both analyses provide valid information but only if the results were integrated in a common analytical system. Consequently, a study of change must consider along with the time frame the level at which a social system is studied to distinguish developments that resulted in faster, gradual and slower, more step-wise processes.

These processes forming tempo and mode of the Azilianisation became particularly important when this development was assumed as an adaptive response to the rapidly changing climate and environment of the Lateglacial (Bosinski 1989). Climate as a globally effective trigger has been previously considered as a motor for large-scale changes in biological communities (Firbas 1939; cf. von Koenigswald 2002). Even though triggers of change and the influence of these triggers on the process of change are important subjects of research, also in archaeology, the connection of potential triggers to changing parameters remains difficult to prove in prehistoric records due to the often uncertain interrelation, the inconsistent presence of chronological indicators, and the decreasing temporal resolution.

Therefore, time and the progress of time are important factors in a study of change. Even though methods of chronological attribution and dating were constantly refined in the last century (Weber/Grimm 2009), time remains a difficult topic in the archaeological record (Crema/Bevan/Lake 2010). In particular, preservation of high-resolution data generally decreases with time, whereas susceptibility to contamination increases for this data. The often demanded need for carefully cross-checking between all chronological indicators (Johnson 1952, 101) and of establishing a relation between the dated material to the archaeological record (Dean 1978) became particularly apparent when precision of radiometric dating results was increased. In addition to the contextual imprecisions, radiometric series also demonstrated the general possibility of meth-

54 Translated by the present author. The original reads: »Plus d'art animalier, seulement des peintures, sur galet et sur paroi, d'éléments schématique ou géométrique. Révolution dans le travail de l'os et du bois de Cerf«.

odological failures. Therefore, all methods should be considered critically concerning the potential failure in the application as well as in the results. For example, apparently reliable (calibrated) radiometric dates also require testing against the environmental context from which the samples were taken and the reliability of the environmental context should equally be confirmed. All reliable chronostratigraphical indicators from a site should be consistent in a synthetic chronostratigraphic position. However, besides reliable results from natural sciences, the archaeological record has to be resolved sufficiently to understand site formation processes and the position of dated material (dated event) in relation to human activities which shall be dated (target event). Therefore, spatial distributions are documented in detail and the most meaningful material is usually selected for radiocarbon dating or other types of radiometric dating (cf. Richter et al. 2009). However, often many human activities remained temporally indistinct. For example, even though sub-assemblages were occasionally clearly identifiable, the chronological relation remained uncertain (cf. Gelhausen 2011b; Jöris/Street/Turner 2011). In other cases, a longer chronological use appeared plausible but the material accumulation remained indistinguishable (cf. Julien et al. 1999; Sensburg 2007). Thus, resolutions of site internal chronologies are limited by the spatial differentiation of the material and its attribution to a single process (Cziesla 1990; Sensburg 2007; Sensburg/Moseler 2008; Gelhausen 2011b). The resolution of archaeological material can subsequently range from site level to intra-site and/or intra-concentration level to a level of single activity sequences performed at a site. As indicated above with the different perceptions of the Azilianisation, the different resolutions of the archaeological record can provide various pieces of information but the resolution should be selected appropriate for the aimed project.

Finally, if a very high temporal resolution was created and a close temporal relation of variation in a potential trigger and changes in another parameter was established, this observation does still not prove that the potential trigger has provoked changes in the studied parameter. These changes could also represent coincidental processes or both, trigger and parameter, responded concomitantly to another factor. Therefore, an attempt of plausibly connecting trigger and responder should be made.

A precise terminology is necessary to relate different parts of prehistoric records at variable levels, in varying resolutions, and from different areas and to communicate these relations as a contribution to further refine studies of these records. The use of defined terms should usually help a reader to follow the presented argument, but in the present study definitions became apparent as playing an important role in causing misconceptions. For example, in the Weichselian Lateglacial records, it often remains a matter of preference which Bølling definition is applied, which definition for the onset of the Lateglacial Stadial, or which attributes to distinguish an Azilian point. To prevent these sources of potential misunderstandings, attempts such as the one for pollen-chronological sequences (Litt/Stebich 1999) that defined hierarchically structured stratotypes and gave increasingly detailed indicators of the defined sections are a good beginning to come to a general understanding. However, this consensus was partially neglected due to local traditions, inapplicability in the local archives, or non-transferability to other proxies. Nevertheless, without a more common consensus, further uncertainties and misunderstandings will appear and prevent comparisons at different scales and of different disciplines. Yet, only this broad comparison can help reveal general developments concomitantly with locally differing movements.

This scientific need for a large consensus to simplify communication is not very different from the methodological topic and the subject of the present study. With a further refinement of the archaeological taxonomic units, a methodological attempt was made to systematise the archaeological record to create a common reference frame in which archaeological units can be compared at various levels. The subject of this study, the Lateglacial record, also reflects the effort to keep a wide-spread community united by common expressions and standards. In some cases this effort was successful, in others it was not. In future, the present study will hopefully be considered among the former.

In summary, to produce meaningful results, studying change requires precision. This precision has to be effective in different parts and levels of the analysis. For example, previously defined terms should be used exactly or rejected to prevent unnecessary confusion if they are not useful. Comparably, the resolution of chronology as well as the analysed part of the record should be accurately clarified to build a solid, though doubtlessly improvable fundament for interpretations. This dissected way of building an analytical basis should prevent misconceptions due to foci on different scales and reveal differences and similarities at comparable levels of the records. Moreover, the knowledge formed in this way could also permit identification of interdependence of the various levels and, as with classic and quantum physics, detect different mechanisms. Thus, a more profound understanding of the development of human behaviour becomes possible. In fact, this study of change already revealed the ability of humans to vary their behavioural repertoires. Exposed to a selective process, this variation helps to abandon a previous standard and to manifest another, better suited variation as a new standard. Thus, studying behavioural change reflects human behavioural adaptation and, thus, helps to understand human evolution.

REVOLUTION OR EVOLUTION?

In the previous chapters, several lines of evidence were collected (see Material, p. 7-244) and compared (see p. 293-564) to consider different assessments of the reorganisation of the Lateglacial social-ecological system in north-western Europe. A detailed schedule of the process of change from the Late Magdalenian to the FMG was established based on material from the Central Rhineland, southern Belgium, and northern France. Analytical values of the studied sites were given and positioned chronologically to reveal the timing of changes in the archaeological assemblages. Then, the observed changes were set in a chronological relation to one another and the climatic and environmental developments and some suggestions about functional changes were given (see Results-Chronology of changes, p. 559-564). After this presentation of the chronological succession, identifying possible mechanisms and causes of the Lateglacial social reorganisation is approached and an interpretation of the results is formulated. Therefore, observed changes are differentiated according to the level to which these changes refer and reasons for these change in relation to changing environments are considered.

According to the present analysis, the process of change in human societies during the Lateglacial occurred on many levels such as the molecular level of LMP dimension, the micro-level of formally retouched artefact groups disappearing, the appearance of the MfCM on the meso-scale, and finally the observable variations in settlement behaviour. In general, the tempo of this process was gradual but a relatively short period was observed in which an accumulation of changes occurred within a few centuries. The appearance of the typical FMG mode of life as defined previously with a greater flexibility in the various behavioural elements such as the raw material acquisition, the blank production, the variety of formally retouched artefacts, in particular of the LMP, and the dimensional changes of these implements as well as the more ephemerally appearing settlement organisation was not related with the prominent climatic event at the onset of the Lateglacial Interstadial. Thus, among the possible triggers for the observed behavioural modifications, climate change in the modern sense of global warming does not appear as a directly effective and/or very important factor. Nevertheless, at the onset of a short but severe cold phase (GI-1d) some 600 years after this rapid warming the tempo of changes appeared accelerated but only some 200 years later, during the subsequent warm phase (GI-1c), a cluster of rapid behavioural changes occurred concomitantly with the establishment of forested environments, which were persistent for several centuries afterwards. This delayed reaction and the

ostensive dissent of the process being an evolutionary as well as a revolutionary process can be explained by the human disposition to form dynamic, complex, and adaptive social networks as a survival strategy and by the developmental history of the original network.

During the Magdalenian resettlement phase, Europe was still a sub-marginal landscape which recovered gradually from the LGM. This cold maximum and the main retreat into southern refuges around 28,000 years ago had resulted in a significant decline of human populations in Europe (Torroni et al. 1998; Pereira et al. 2005; Soares et al. 2010). However, some 10,000 years later, the human groups of the Iberian/south-western French refuge had recovered enough to expand during the Late Pleniglacial into the continuously growing territories in Northern Europe. These territories grew with the regression of ice-sheets and the subsequent disappearance of continuous permafrost. A gradual recolonisation by pioneer vegetation followed by first arctic animal species appeared. However, this recolonisation depended on various factors such as soil development and shelter. Consequently, a continuous, wave-like advance seemed improbable. The recolonisation must rather be visualised as a patchy wiggling or weaving movement, most probable along larger water courses which provided sufficient security and stability of water supply in the arid landscape. This uneven movement resulted in a landscape formed by different biotopes in which resources were unevenly distributed. Assuming that some of these resources were necessitated for a human survival, a clustered distribution of sites can be assumed (cf. Butzer 1982) and is, in fact, still identifiable around 16,000 years cal. b2k by the various Late Magdalenian centres in the Thuringian Basin, the Central Rhineland, or the Paris Basin. However, the intensified aridity during the Heinrich 1 event caused possibly a faster ice sheet decline and strengthened the aeolian deposition of fine-grained sediments. Although loess deposition, possibly in the form of loess storms, affected parts of the landscape at the onset of the studied period, the examples from the Late Magdalenian inventories found within these aeolian deposits prove that this climatic and environmental nuisance formed no restriction to the expansion process. In particular, the almost year round occupation of Gönnersdorf (Street/Turner 2013) indicates that this possibly seasonal phenomenon of winds loaded with sediment was no limiting factor. However, a low population density (cf. Bocquet-Appel et al. 2005; Kretschmer 2012) in combination with a persisting climatic and environmental instability required large networks to secure the survival of clustered groups migrating into the newly available landscapes and the stability of the human metapopulation in these insecure surroundings (cf. Hanski 1998). Various strategies to reduce risk and uncertainty and to compensate for stress caused by minor variations of their environments were applied to ensure survival across critical periods (cf. Stein Mandryk 1993). For instance, these groups had to conform to a very conservative lifestyle to remain connected and able to communicate across these large areas to allow for a sustenance of security networks. Thus, survival referred in this period to single individuals as well as the community and, thus, these strategies formed the resilience of the Magdalenian.

In particular, the subsistence strategy was modified during the Late Pleniglacial to provide the largest possible nutritional security which was expressed by a generalist approach (Gaudzinski/Street 2003) and first steps of the broad spectrum revolution in the diet reflected in the incorporation of higher proportions of smaller mammals (see **tab. 86** and p. 543-546; cf. Munro 2003; Zeder 2012), fish, birds (cf. Street/Turner 2013), and, perhaps, marine resources (Pétillon 2008a; Langley/Street 2013). Furthermore, evidence shows that the Late Magdalenian hunters exploited their prey to a degree comparable to an ethnographic »nothing is wasted« ideal (cf. Pasda/Odgaard 2011). However, this intensive alimentary exploitation and the partially seasonal availability of resources required also a strictly organised mobility behaviour in the landscape. Mobility patterns were additionally shaped by finite or limited resources such as wood. Perhaps, the poverty in wood during the arid Heinrich 1 event resulted in a complex composite weapon system which could save this resource. Nevertheless, hunting equipment which was used at a distance requires

a relatively high precision and, thus, the organic and lithic production were adapted to serve high quality products of a consistent quality and regularity. To guarantee this precision on which the hunting success and, thus, the alimentary security of the group partially depended, humans have to be trained (cf. Pigeot 1990; Schmider 1992e) and regularly monitored to prevent variation (Eerkens/Lipo 2005; Hamilton/Buchanan 2009).

These compensating behaviours paid tribute to an enormous need for security (Maslow 1943) in these human groups and resulted in a remarkable resilience. For hunter-gatherers, a predictable environment contributes to a feeling of security because the predictability allows for planning and preparation (Rowley-Conwy/Zvelebil 1989). Thus, predictability of the environment is an important factor for hunter-gatherer behaviour (Halstead/O'Shea 1989b). However, as demonstrated by the Late Magdalenian, hunter-gatherers can also cope with variable environments, for instance by allowing for more variation within their behavioural patterns (Jochim 1991). This ability to adapt was also considered as an important factor in the resilience of a social-ecological system (Walker et al. 2006).

This pattern is also seen in the Late Pleniglacial where, besides the high conformity, the ability to adjust to short-term variation was sustained. This ability was reflected by the sustenance of almost continuous variation on molecular and micro-scale levels such as variability in the use of hunting equipments (% LMP), in the lithic equipment (Simpson diversity index of formally retouched artefacts), and the provisioning of lithic resources (% and number of cores, exploitation of cores) as well as a variety of sites (site types, function index). In addition, the quick adjustment was also observable on a meso-scale level when unfamiliar species such as red deer, elk, and wild boar were incorporated in the prey spectrum soon after their arrival in the sub-areas. The material from Bois Laiterie and the south-western part of Gönnersdorf reflect this adaptability of the Final Magdalenian.

The seasonally variable availability of the newly appearing faunal species was low and the increasing availability of a variety of larger mammal species allowed for an occasional neglect of the strict »nothing is wasted« ideal. Moreover, the increasing surplus created wastes which could attract scavengers and vermin. Thus, to keep regularly visited locations free of attractive faunal residues, burning of these wastes was a possible solution which first appeared during the transition towards the Lateglacial Interstadial. However, the occurrence of the burnt material could also indicate the appearance of a different method of extracting grease but since the variety of the burnt faunal remains appears not very selective (Bignon/Bodu 2006), this possibility is considered less probable. Another possible explanation for the appearance of burnt instead of fragmented bones could be provided by the seasonal evidence. According to seasonal indications, the sites where the burning of bones occurred were tendentially used in winter. Thus, the meagre winter/dark season game was possibly no longer used for nutritional provision and instead the summer provision was consumed. Nevertheless, according to this scenario the nutritional stress in winter had certainly decreased. Possibly, this increasing ability of the applied subsistence strategy to provide for the dark season by surplus created in the summer months was also detectable in the appearance of super-specialised sites which often resulted from recurrent horse hunting episodes in favourable valley situations. This type of site also led to a variation on the mega-scale by the creation of a less restrictive organisation of space use at sites around 15,000 years cal. b2k, perhaps, due to the decreasing loess deposition. Combined with shorter intervals of returning to the site, the smaller sediment cover permitted the reuse of material previously transported to the site. This reuse led to a decreasing need to transport additional materials to the site. However, on the tendential winter sites, a classic Late Magdalenian organisation was preserved (Jöris/Terberger 2001). These locations were still clearly structured and, thus, appeared not as intensively used as the tendential summer locations. Although some Late Magdalenian occupations seemed similarly tidy such as Gönnersdorf IV, recurrent settlement dynamics overprinted the originally

tidy structure in the majority of larger Late Magdalenian concentrations (Terberger 1997; Sensburg 2007; Sensburg/Moseler 2008).

These indicators mainly from the faunal and the spatial record suggest that the Magdalenian hunter-gatherers, which were adapted to the harsh Late Pleniglacial environments, reacted to an apparently more favourable period beginning in the second half of GS-2a. In this favourable period, non-conformity to an intense exploitation strategy was not punished and/or sufficient surplus could be produced to provide for harsher seasons. Subsequently, the Late Magdalenian was modified by adaptations to a more favourable and less punishing environment, mainly by allowing for a wider flexibility in the behavioural repertoire. Moreover, the MfCM and the Early Azilian were shown to be different on various scales but the remarks on subsistence strategies and seasonality of these sites suggest an interdependence of these two complexes.

Furthermore, with the increase of vegetation productivity and the appearance of the first shrubs during GI-1e, previously limited resources such as plant fibre, plant tars, and wood became available in increasing amounts. This change allowed for a more profound change on the molecular scale in the hunting equipment (LMP types – shapes and dimensions). The effectiveness of these new systems seemed to slowly replace the more complex organic systems. Perhaps, the gradually decreasing availability of antler material further contributed to this decline. With the continued presence of the vegetation resource, the projectile system could be altered which was possibly also detected on the molecular level of the variance of LMP thickness around 14,200 years cal. b2k.

However, the return of harsh climatic conditions during GI-1d, including the deposition of some massive coversands in parts of Northern Europe (Kolstrup 2007), were related in the record with the definitive disappearance of long distance connections, in particular the relations from the Central Rhineland to the areas in the south-east, and a further increase of the LMP variability (LMP types – shapes and dimensions). The former reflected changes in the socio-economic networks between different regions and can therefore be related to the meso-scale. Shortly after the onset of GI-1d, the appearance of small, centrally organised concentrations and the decreasing function variability revealed also changes in the spatial behaviour and, thus, referred to the analytical mega-scale.

Perhaps, the dispersal of more coarse-grained material hindered the travel in some regions and possibly led to the emigration from the most intensely affected areas. In addition, with the previously seen greater flexibility of the behaviour, the conforming to common standards which sustained large social networks must be questioned. With the potential population increase, new ideas about hunting equipment could have been introduced and/or an adaptation to optimise the hunt on returning colder adapted species became useful. Nevertheless, population pressure due to emigrants in the areas unaffected by the deposition of coversand was not observable by a greater density of sites or an increasing exploitation intensity of the prey. In fact, the number of sites decreased and also the intensity of their use indicated no apparent increase of the number of inhabitants. These indicators rather suggested a decreasing population at the end of GI-1d. Occasionally, the diversity of the faunal record was increased but it seemed that the modified Magdalenian hunters were no longer aware of the highly conservative behavioural patterns to compensate for nutritional stress. During this transition from GI-1d to GI-1c_3, the graves in the Central Rhineland and the period with the highest density of changes relating to different scales occurred. The evidence from Irlich (Orschiedt/Berg/Flohr 2011) suggested that malnutrition might have affected these hunter-gatherers and occasionally favoured fatal diseases or resulted in starvation. Nevertheless, these graves show some classic Magdalenian behaviours such as the use of ochres, figurine art, and the deposition of complete bodies in an earthen grave (cf. Wüller 1999). However, these behaviours were previously unknown from this region. Perhaps, a wish to return to old behavioural recipes was thereby reflected that would prove the severity of this situation. The engravings at Gouy were possibly an expression of a comparable wish to return to the »old ways«.

Studies of complex adaptive systems in modern geography made a distinction between planning strategies of just-in-time and just-in-case (Alfasi/Portugali 2004). If this approach is transferred to hunter-gatherer groups, the transmission of various behavioural recipes without direct necessity is a just-in-case strategy and clearly helps to compensate for insecure environments. Among modern Evenk in Siberia, Ole Grøn observed that these hunter-gatherers knew about cyclic developments in their environment and had a concept of the interactions which he assumed comparable to the modern concepts of ecology (Grøn 2012). This knowledge was due to the lack of scientific terms transmitted in a spiritual terminology and the shaman of the Evenk kept this knowledge. A comparable case of a transmission of ecological cycles by the use of myths was previously reported from the sea people (*tareumiut*) and the inland people (*nunamiut*) of the Alaskan Iñupiat Eskimos (Minc/Smith 1989). Images could play an important role in these transmission chains. The very naturalistic engravings of animals on the slate plates of Gönnersdorf and Andernach are, therefore, explicable as relevant indicators for a transmission strategy. In particular, since some of these images showed species that were almost extinct at this time such as woolly rhinoceros or mammoth (cf. Stuart 2005; Bosinski 2008) or species which could only be found at a distance of several hundred kilometres from the sites such as seals (Hansen 2006), these potential instructions were certainly not meant for an instant use near the sites. In this context, the Late Magdalenian seemed to apply a just-in-case strategy that together with the naturalistic images became infrequent at the end of the Late Pleniglacial and during the early Lateglacial Interstadial. Thus, the transmission of behavioural recipes without direct use might not have been sustained in the modified Magdalenian, possibly due to the lack of occasional need and punishment of non-remembering.

At the end of the cold period, light forests rapidly expanded in the study area but the environment and the climate remained unstable for the next centuries. Probably, this instability led to the inability to successfully adapt to this environment because the important factor of predictability (Halstead/O'Shea 1989b) was difficult to establish. A possible way to compensate for changing resource availability even within yearly rounds is the change of group sizes (cf. Stein Mandryk 1993). Thus, were the hunter-gatherer of the FMG perhaps organised in smaller groups that roamed the area? Smaller groups could not split up easily into special task groups and, hence, the differentiation between the sites would decrease. The result would be a more collector-like settlement system (cf. Binford 1980) with some agglomeration camps which allowed for the exchange of information at least with the neighbouring groups. Seasonal revisiting of sites with this undifferentiated site type would produce the sub-urban type of space use.

Numerous changes occurred in the 200 years following the forestation. These changes seem to reflect the collapse of the modified Magdalenian way of life. However, based on the adaptations introduced previously, this collapse gave rise to the fully established FMG in the Central Rhineland and, probably, the Paris Basin. In the north of France, another set of adaptations was chosen on the molecular and micro-scale to create the new standard behaviour. Thus, in addition to the absence of evidence for long distance relations, different behavioural patterns are observed in the study area reflecting the trend towards a regionalisation in this period. Even though the lower horizons at Hangest-sur-Somme III.1 and Conty show differences in the material remains, the faunal assemblages indicate that the regionalisation was rather caused by a different function than a completely different way of life.

However, after this long period of gradual change over at minimum 2,100 years, why and how could a collapse of the Magdalenian and the emergence of the FMG appear so rapidly within less than 500 years? According to the social brain hypothesis, formation of beneficial alliances such as the Late Magdalenian occurred as an answer to social competition and led to the development of cooperative behaviour (Byrne 1996; Charlton 1997; Dunbar 1998). The members of this cooperation agreed on norms and limits in the behaviour to which they conformed for a general benefit. Although some variation within these behavioural

limits were allowed and essentially needed to remain flexible concerning the natural demands, some social restriction for complying with these limits are necessary to let the majority consider the alliance or, more precisely, the following of the behavioural recipe as generally beneficial. Such a balance of equality is particularly required in an environment with restricted resources where competition and accordingly beneficial alliances can become essential for survival. In modern politics and environmental studies, the reason for this conservative behaviour would be called risk mitigation or management because these groups had to survive in an almost empty social space that faced a dense and rigid environment. Resilience is the outcome of this flexible conformistic behaviour. Large distances needed to be crossed to sustain securing social networks. Therefore, it is unsurprising that the highly adaptable but also highly conformist social system of the Late Magdalenian was the last almost pan-European hunter-gatherer entity which shared a common set of traditions from Portugal in the west to eastern Poland and from the Mediterranean to the limits of the North European Plain.

Breaking the limits of alliances, for example due to a poverty of resources, this behaviour is either isolated or punished by other allies or causes the collapse of the existing agreement. Thus, single, small infringements to an agreement can perhaps be tolerated by the community that needs to remain particularly flexible in dispersedly settled areas. Therefore, an increasing diversification and, thus, decreasing pan-European conformism revealed by the archaeological material was probably not regarded as dangerous in the subsequent periods of the Lateglacial as well as the Holocene. Nevertheless, alliances break up rapidly after a threshold of behavioural flexibility is surpassed. This threshold is when a new alliance offers to be more convenient or competition promises to be more beneficial than allying (cf. Han/Pereira/Santos 2012). However, a new alliance can only fulfil its promises if it is supported by a substantial part of the community members. Thus, the emergence of new alliances and, consequently, new rules for socially selected behaviour often occur in a phase transition-like manner (cf. Gavrilets/Duenez-Guzman/Vose 2008) meaning that some gradual changes occurred prior to an accelerated collapse of the old alliance or agreement and the emergence of the new alliance. Comparably, resilience theory also suggested changes prior to the collapse phase (Abel/Cumming/Anderies 2006).

Furthermore, the Lateglacial transition was compared to people adopting to sub-marginal landscapes before. Considered from the point of view of a Late Magdalenian hunter-gatherer: Was the environment becoming more sub-marginal or was the transition into the Lateglacial Interstadial rather perceived as increasing prosperity? And what happens to hunter-gatherers confronted with a rich and less punishing environment than before? According to the present results, the transition rather seemed initiated by increasingly decadent behaviour in a landscape producing significant surplus for a society which was highly adapted to intense faunal exploitation. The lithic assemblages of Bad Breisig, sector 2 of Le Grand Canton, and concentration III of Gönnersdorf showed that humans tend to exploit resources that appear to be plentiful and easily accessible without longer transport distances in a wasteful, decadent manner independent of their environmental and behavioural background.

Based on this reasoning, interactions of humans with their surrounding ecosystem can be assumed to shape and limit the resilience of these often inert human systems. The resilience and the ecological tolerance range reflected the ability of past societies to adjust their policies of population growth and economic demands in response to climate and environmental change.

In general, the results of this study are comparable to the findings of an analysis about the impact of volcanic eruptions on past societies (Grattan 2006). Minor impacts were shown to have major effects on societies which were already destabilised, whereas major impacts had only little or no impact on resilient communities. Comparably, at the onset of the Lateglacial Interstadial, the impact of climate and environmental change was compensated by the resilient Magdalenian groups through minor adaptations for almost an-

other millenium. However, continuous uncontrolled variation during this period resulted in a destabilised alliance which could no longer persist during less severe climatic and environmental fluctuations.
In conclusion, climate change, in particular global warming, is no disaster for well connected societies that are flexible enough to adapted to changing conditions. However, if social agreements are already disintegrating the impact of minor changes can have major consequences. Thus, also resilient societies facing a climate change must consider long-term results of their small-scale adaptations and strengthen social cohesion to prevent a later failure due to minor external triggers.