LIVING ON THE LAKE IN PREHISTORIC EUROPE

150 years of lake dwelling research

Edited by Francesco Menotti

LIVING ON THE LAKE IN PREHISTORIC EUROPE

The chance discovery in 1854 of a prehistoric lake village on Lake Zurich triggered what we now call the 'lake-dwelling phenomenon'. One hundred and fifty years of research and animated academic disputes have transformed the phenomenon into one of the most reliable sources of information in wetland archaeology.

This definitive volume provides an overview of the development of lake village studies, explores the impact of a range of scientific techniques on the settlements and considers how the public can relate to this evocative and exciting branch of archaeology. It explains how the multidisciplinary research context has significantly improved our knowledge of prehistoric wetland communities, from an environmental as well as a cultural perspective.

Living on the Lake in Prehistoric Europe brings together the most prominent scholars in the field to create an authoritative survey of the past, present and future of lake village studies.

Francesco Menotti is Research Associate at the Institute of Archaeology, University of Oxford.

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150 years of lake-dwelling research

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TO ALL STUDENTS

CONTENTS

FIGURES

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FOREWORD

How often it is that discoveries which change the course of a discipline come about as the result of chance. An unusually dry summer and the power of the mountain ice to trap what water there was meant that the communities living around Lake Zurich looked out on a much reduced lake level in the winter of 1853–4 – a phenomenon which the citizens of Ober-Meilen turned to good advantage by reclaiming areas of lake shore to create extensions to their vineyards. In digging out mud, used to raise the level of their new plots, timber piles were exposed among which the workers found a range of artefacts and bones. This, in itself, was not an unusual occurrence: similar finds had been made from time to time over the previous 30 years or so, but this time there was an inquisitive village schoolmaster on hand, Mr Aeppli, who reported the find to the local naturalist, Dr Ferdinand Keller President of the Antiquarian Association of Zurich. That meeting in the icy January of 1854 was to set in motion an enthusiasm for the study of 'pile villages' that swept through Europe in the late nineteenth century catching up in its wake not only antiquarians and scientists but also collectors and the general public.

The avid search for lake villages and the public engagement which accompanied it is easy to understand. Quite simply, with so much of the timberwork preserved, the sites were evocative. They were also rich in a great variety of artefacts including a wide range of organic goods of the kind seldom seen before. Given so much, the imagination could easily conjure up the people, and artists could offer to an eager public reconstructions of idyllic prehistoric lifestyles. For many people the Swiss lake villages made archaeology live for the first time – they could almost touch their ancestors whose lifestyles had been surprisingly similar to their own.

Keller's efforts to discover and excavate lakeside villages were tireless and his regular, detailed and beautifully illustrated reports soon made his discoveries widely known, not least through their English translations edited by J.E. Lee and published in 1866 as The Lake Dwellings of Switzerland and other parts of Europe. Such was the popularity of this work that a 'greatly enlarged' second edition appeared 12 years later. No doubt many of the purchasers were the travelling elite who flocked to Switzerland every year.

The volume before us presents a collection of papers in celebration of the 150th anniversary of Keller's first excavation at Ober-Meilen. It begins with historical overviews laying out the achievements of 'lake village' studies in the six countries embracing the Alps where the very distinctive science of wetland archaeology was born. There follow two sets of papers, the first exploring the impact of a range of scientific techniques on the lake-edge settlements, the second covering themes which may broadly be called outreach. It is a rich and varied mix which serves well as a microcosm of archaeological endeavour and achievement over the last century and a half – Keller might reflect with mild satisfaction on the fruit born of that January encounter with the village schoolmaster. We, for our part, will ever remain indebted to Francesco Menotti for bringing together such a harvest for us to enjoy.

BARRY CUNLIFFE
Oxford
November 2003

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Finally, I would like to express my sincere gratitude to Professor Andrew Sherratt for believing in me, for encouraging and guiding me throughout my academic career.

Francesco Menotti

INTRODUCTION

The lake-dwelling phenomenon and wetland archaeology

Francesco Menotti

Introduction

One hundred and fifty years ago, as a result of a dry and harsh winter, the water level of Lake Zurich decreased considerably, exposing ancient remains of lacustrine villages. Of course, traces of ancient dwellings on lakes and marshes had been known well before 1854, but, for some reason, they had never been officially reported to the authorities. It took the efforts of a school teacher, Johannes Aeppli, to trigger a phenomenon that would have enormous implications on wetland archaeological studies in general. Full of enthusiasm about the discoveries, Mr Aeppli promptly contacted the Antiquarian Association in Zurich and the Ober-Meilen prehistoric lacustrine dwelling was soon examined by the Swiss naturalist Ferdinand Keller, who by the end of 1854 published a detailed site report: *Die keltischen Pfahlbauten in den Schweizerseen* (Keller 1854). It was this publication that initiated the widespread interest in the lake-dwellings. The quest for lake-settlements rapidly spread around the entire Alpine region (Chapters 1–6 this volume), central Europe and even across the English Channel (Coles Chapter 7 this volume). By the turn of the century, hundreds of sites had been discovered and a number of scholars had already begun to study them.

In this embryonic state, archaeological research was far from scientific. In fact, sadly enough, the main purpose of the lake-dwelling ‘rush’ was purely lucrative. Hundreds of improvised ‘antiquarians’ made their fortune by selling illegally collected lacustrine artefacts to private collectors all over the world.

A transformation in lake-dwelling research did not occur until the first decades of the twentieth century, when a few scholars started to question Keller’s theory, which had remained unchallenged for more than 70 years. Basing their evidence on more scientific grounds, Reinerth (1932), Paret (1942) and finally Vogt (1955) advanced the idea that the lake villages were not built on stilts and platforms above the water, but had actually been constructed on dry ground near the lakeside. The *Pfahlbauproblem* (the lake-dwelling dispute) had begun! The academic dispute would not be resolved until fairly recent times and it is a sad reflection of this dispute that, in 1954, the 100-year jubilee of the pile-dwellings was celebrated by a uniform denial of their existence.

But, as the proverb says: 'every cloud has a silver lining!' As a result of this long dispute, scientifically based research programmes were developed. In fact, once the *Pfahlbauproblem* was no longer a problem and all scholars agreed that the typological distinction between the various lacustrine habitations depended upon cultural as well as environmental factors, the focus of research shifted to chronology.

Chronology

It is difficult to pinpoint exactly the time when humans decided to settle wetland environments. We have always been fascinated by water, no matter what it was; a sea, a river, a lake or a simple marshy pond, and certainly we have been linked to them in a way or another since the dawn of humanity. It is not until 'recently' though that humans began to settle humid environments systematically, building their settlements within them, and fully connecting their everyday life to that particular ecosystem.

Although we have 'sporadic' episodes of wetland occupation in the Mesolithic, see for instance Star Carr in England (Clark 1954; Coles Chapter 7 this volume) and a few sites on Lake Feder in southern Germany (Schlichtherle Chapter 2 this volume), the large-scale settling of lacustrine environments did not occur until the Neolithic.

A number of theories have been formulated regarding the origin and spread of the lake-dwelling phenomenon in the Alpine region, but the most plausible one seems to argue for a southern provenance. This hypothesis is based on palaeobotanical analyses of a specific kind of wheat also called the 'lake-dwelling wheat' (*Triticum durum/turgidum*), which is commonly found on most of the wetland sites around the Alps. Surprisingly enough, the origins of this wheat are to be located in the Mediterranean area. Traces of it have in fact been found on some of the Catalan lacustrine environments near Banyoles in south-eastern Spain and on Lake Bracciano (central Italy). They both date back to the sixth millennium BC. The northwards expansion around the fifth millennium BC took two directions. One started in eastern France, cut through the Swiss Plateau, and finally reached southern Germany; and the other cut across the Slovenian marshlands on the eastern parts of the Alps, eventually reaching Austria and the Bavarian region. The spread of 'lake-dwelling wheat' around the Alpine region was completed at the beginning of the second half of the fifth millennium BC (Schlichtherle 1997).

Thanks to the remarkably well-preserved wooden remains, dendrochronological analyses have given us a fairly clear picture of the Alpine lake-dwelling chronology (Billamboz Chapter 8 this volume). The lake-dwelling phenomenon started in the late fifth millennium BC and ended around the seventh century BC. As much as we would like to see it as homogeneous in terms of human occupation, archaeological evidence argues for a marked discontinuity. We have in fact, three major hiatus, plus a number of short and regional interruptions. Why did the Alpine region lake-dwellers abandon the lakes sometimes and reoccupy them later? Recent studies show that the cause of abandonment could be either cultural or environmental, and in some cases even a combination of both. The studies of Magny (1993, 1995, 1999 and Chapter 9 this volume) show that there is plausible correlation between climate and the lake-dwelling occupational patterns. Periods of favourable climate coincide with period of lake-dwelling occupation, whereas abandonment is the result of climate deterioration. As it is pointed out by Pétrequin though, the relationship climate–lake shore occupation does not always work (Pétrequin *et al.* 1998, 1999, 2002 and Chapter 3 this volume). There are in fact periods when the climatic conditions in the lacustrine environment were favourable, but the lake shores were not settled anyway (e.g. the Bell Beaker period). It is therefore vital to consider all the variables, which can be neglected with a simple environmental deterministic approach (Menotti 2003 and Chapter 14 this volume).

Science, technology and cultural studies in wetland research

A major step forward in the latest lake-dwelling research is the application of multidisciplinary scientific analyses to study not only straightforward chronological occupational patterns, but also cultural and socio-economic aspects of those prehistoric wetland communities.

Despite the great availability of organic material found on wetland sites, we still know very little about those prehistoric lacustrine groups' way of living. Micro-botanical (Jacomet *et al.* 1998 and Chapter 11 this volume) and osteological (Schibler and Jacomet 1999 and Schibler Chapter 10 this volume) analyses have helped us understand those communities' subsistence and economy, but we are still far from fully comprehending how social structure was organized within the single societies. We know for sure that they were a mix of agriculturalists, pastoralists and hunters, with of course some fishing activity around the water basins. Trade was also an important aspect of the lacustrine people's everyday life and pottery distributions, as well as other traded goods, are an eloquent proof.

Another developing research field, which is booming at the moment, is large- and small-scale landscape studies, particularly in relation to the single lacustrine settlements and their catchment area. A vital role in this new research area has been played by computers and in particular the application of GIS (Geographical Information Systems) analyses (Menotti 1999, 2001, 2003 and Lock Chapter 13 this volume). Computer technology also contributes to an often under-considered, but crucial aspect of the lake-dwelling research, namely detection and discovery of new wetland sites. The combination of satellite imagery and GIS-integration of disparate data sources is an eloquent example of the fundamental role of IT in wetland studies (Lock Chapter 13 this volume).

Finally, a great contribution in lake-dwelling research has been made by underwater archaeology. In fact, for various reasons, a number of lacustrine sites are presently underwater and the only way to excavate and study them is by using diving facilities. Underwater archaeology on lake-settlements started as a sport recreational activity, but thanks to the dedication of a few scholars, it has become an essential part of wetland research (Ruoff 1981; Arnold 1986; Hafner 2001). Excavations are as meticulous as the ones on dry land and, because of the undisturbed and well-preserved archaeological material, the final results should be even better (Hafner Chapter 12 this volume).

The lake-dwellings and the public

There has always been a wide gap between the academic world and the general public. First-year archaeology students are often told that studying the past could improve people's future. Human beings have to know what they did in the past in order to plan a better future. If this is true, why is this opportunity hindered by a lack of communication between the few who know and the rest of us? Of course there are museums, TV documentaries and popular books available, but the ratio of academic knowledge and public exposure to it is still extremely low. The information people receive from the academic world is limited and, in many ways, the public feels ostracized. In some cases, when scholars decide to bridge this gap, they are often criticized for being superficial or seeking 'cheap' popularity.

Of course there are various ways of informing the public without being too pedantic. Museums play an important role, but as Schöbel argues, a simple display of artefacts is not good enough. People themselves have different expectations. Children need to be guided in a different way than adults do, and therefore the organization of tailor-made initiatives is crucial in order to attract and make more people interested in the discipline (Schöbel 2002 and Chapter 15 this volume). Another effective way of informing the public is what Leuzinger calls 'hands-on archaeology'. This initiative is closely connected to a research area which is currently thriving, namely experimental and applied archaeology. In this case, not only do people have that chance to see how artefacts were really made in prehistoric times, but they also have the opportunity to experiment with them and see how the tools work. It is a two-way interaction: the public feels involved and the archaeologists have their experimental tools tested 'for free' (Leuzinger Chapter 16 this volume).

Conclusions

If it is true that our future depends on our past, then how difficult is it to predict the future of wetland archaeology as an academic subject? With a collection of 18 chapters, this volume takes the reader through the progressive development of the discipline from Ober-Meilen to the present. These 150 years of wetland research 'evolution' are nicely synthesized by Hochuli and Schaeren in Chapter 17, and emphasized and placed in a broader European context by Sherratt in Chapter 18.

A fortunate discovery and an initial lucrative artefact business have turned into one of the most precise sources of archaeological evidence. But, like the artefacts that it yields, wetland archaeology is extremely delicate. High research costs, preservation, poor research management and academic disputes are threatening the discipline and, consequently, our well-preserved heritage.

Studying and protecting the past is no longer a task of a few well-educated individuals; it has become a communal effort by our society. Separation is no longer an option, academia and the public need to join forces to achieve the best results. If we have to improve our future, it has to be done together!

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Part 1

DIVERSITY IN UNITY

Regional frontiers in lake-dwelling research

1

LAKE-DWELLING STUDIES IN SWITZERLAND SINCE 'MEILEN 1854'

Ulrich Ruoff

Introduction

The first report on Swiss lake-dwellings was published in the *Bulletin of the Antiquarian Society of Zurich* in September 1854. In the report, Ferdinand Keller described the prehistoric finds discovered at Meilen on the Lake of Zurich. Those archaeological remains had been brought to his attention earlier that year by Johannes Aeppli, the local school teacher. Keller also notified his readers of similar sites, with piles, in the Lake of Zurich and in the Lake of Bienne, in the West of Switzerland. The sensation created by the report was due to a daring interpretation of these finds as evidence of prehistoric villages built on piles in water. On the basis of the large number of objects, Keller drew the conclusion that they must denote the existence of a proper settlement, rather than isolated fishermen's huts. He thought that the people who lived in them had probably been Celts because of the richly decorated bronze objects discovered primarily in the Lake of Bienne.

A daring interpretation of unusual finds that led to bitter disputes

In his report Keller discussed a number of the questions which will be discussed here. He considered primarily whether the dwellings were built in the water or on dry land, and he opted for the former hypothesis (Keller 1854). In order to back up his theory he compared the Swiss sites with lake-dwellings in New Guinea and in New Zealand. The sketch of the reconstruction of the village at Meilen published in his report was based on drawings of a settlement at the Bay of Doreh in New Guinea published by Dumont d'Urville. Keller, however, did not concern himself with the technical details of the New Guinean houses; he presumed without further discussion that the Swiss houses had not been built individually in water, but on platforms. He probably came to that conclusion, because the piles stood very near to each other (Figure 1.1). Despite the fact that the lake-dwelling image was based on unreliable evidence, it was repeatedly used as a model for further illustrations and respected as a scientifically based reconstruction.

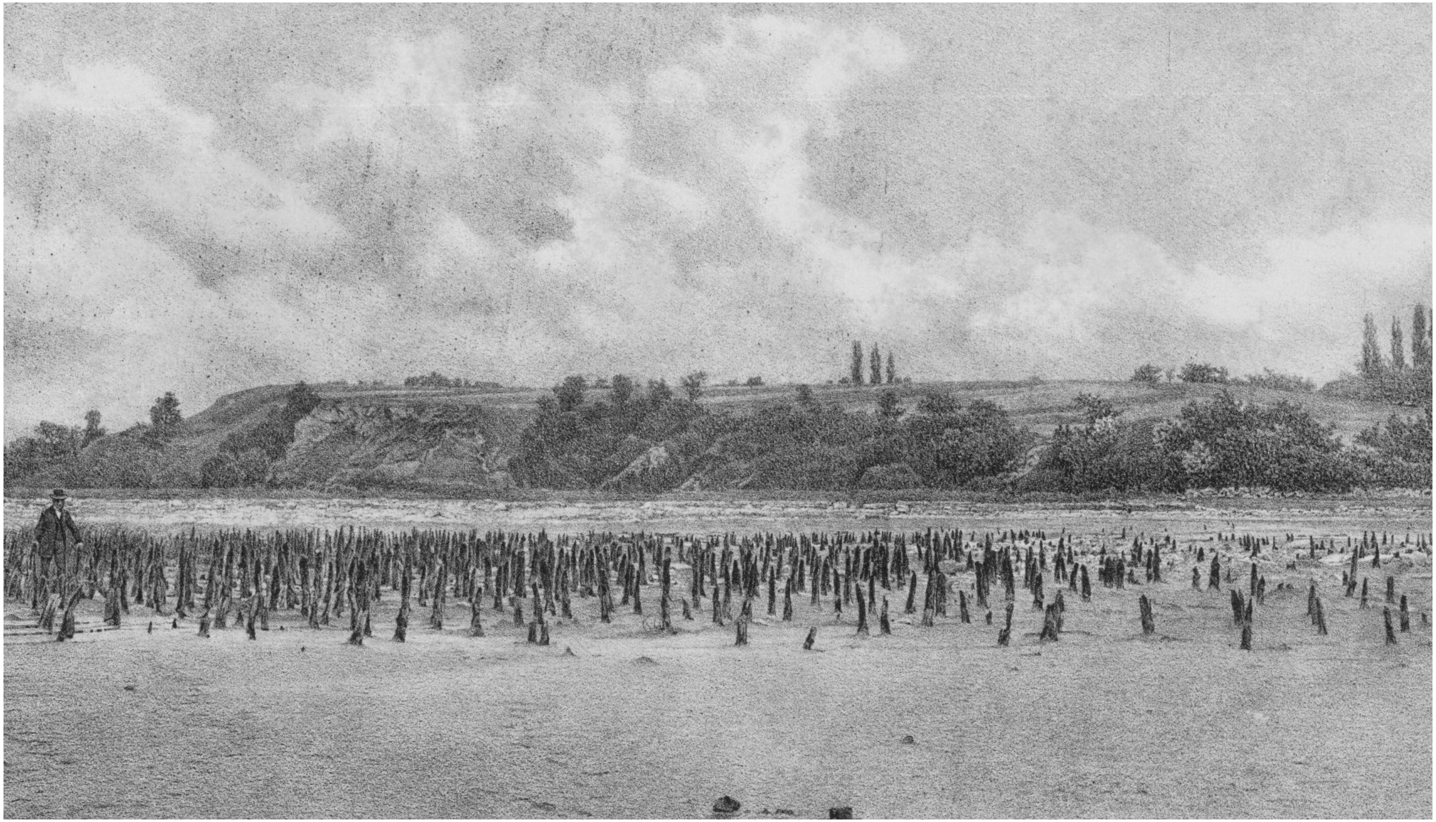

Figure 1.1 A field of piles on Lake Bienne *c.* 1870 after the water-level had been lowered in connection with the so-called first Juragewässer-Correction. As the piles stood very near to each other they were erroneously regarded as the substructure of a platform on which the dwelling houses had been built. Lithograph in the *Pfahlbaubericht* 7, 1876.

The abundance of well-preserved finds raised questions about the cultural aspects of the lake-dwellers. In his second *Pfahlbaubericht* (Lake-dwelling report) published in 1858, Keller set forth the idea that the lake-dwellers had a relatively well-developed culture (Keller 1858). He argued that farming must have been a prerequisite of such large settlements. The remains of plants and bones that provided evidence for this hypothesis were therefore examined. Carbonized grains of different kinds of wheat and barley were also examined and identified. Since the 1860s contributions pertaining to natural sciences have been a regular part of *Pfahlbauberichte*.

News about the discoveries at Meilen immediately inspired many scholars and collectors to search for and study similar sites in other lakes, and soon a number of these antiquarians were actively engaged in lake-dwelling research. It would be impossible to mention all of them, but two names definitely stand out: A. von Morlot, a Bernese geologist, who dived using a bucket as a self-made diving helmet in the Lake of Geneva off Morges on 2 May 1854, and F. Troyon, the keeper of the museum of Lausanne, who accompanied him on the boat. Troyon published *Habitations lacustres des temps anciens et modernes* a few years later (1860), in which he shared Keller's theory that the sites were, indeed, lake-dwellings, but amplified it with views pertaining to the history of the presumed civilization of the inhabitants. These were subsequently criticized. Nevertheless, archaeologists all over Europe took a keen interest in the fascinating discoveries, the number of which was rapidly increasing. Over a hundred sites had already been reported in the *Pfahlbauberichte* by the early 1860s.

It is not surprising that the news about the lake-dwellings spread rapidly among the general public. People quickly became interested in their origins and the romantic ideas sketched about the lake-dwellers greatly appealed to the popular imagination.

The idea of the lake-dwellings on platforms rapidly became accepted as a scientific fact. The other explanation for the piles initially considered by Keller, whereby the villages had been built on the shores during periods of low water levels, was soon forgotten. Even the evidence provided by the floors of houses, which were made by laying round pieces of wood side by side and discovered in the peat layers of small dried up lakes, was hardly discussed. The study of the construction of such settlements showed that they had been built on top of each other and that they must, therefore, have dated from different periods. Yet this evidence was instead interpreted as layers of artificial islets and was of secondary importance to the prevailing idea of the villages built in the lakes. The so called '*ténevières*' or stone hills found especially in the lakes of western Switzerland were regarded as artificial islets, but not settlements. It was only in the early twentieth century that the scholars began to question the theory, arguing that they were remains of houses, but not necessarily on stilts.

The so-called 'lake-dwelling fever' turned amateurs into professional researchers. A good example is that of Jakob Messikommer, a local farmer who undertook archaeological excavations at Robenhausen, a site he had discovered on Lake Pfäffikon, Canton Zurich, in 1858 (Messikommer 1913). He certainly deserved the honorary doctorate given to him by the University of Zurich. The innumerable objects discovered at Robenhausen made the French scholar G. de Mortillet call one of the Neolithic periods 'Robenhausien, ,and the fabrics discovered by Messikomer are of scientific interest still today.

The great interest in the lake-dwellings shown by the general public and scholars then gave rise to disputes about the question of who really had discovered them. It seemed unfair to Johannes Aeppli that despite the fact that he had spotted the lake-dwelling remains first, Keller alone was taking all the fame and credit for the discovery. In their dispute, Keller and Aeppli seemed to have forgotten that local fishermen had always been aware of sites full of piles and had also found prehistoric objects around them. Indeed, it was not the settlement discoveries, but Keller's interpretation of them that had given rise to the study of the lake-dwellings.

New finds, but no large-scale excavation yet

Due to the so-called 'Juragewässerkorrektion', an enormous engineering feat to control floods in the Jura area carried out in 1869–88, the water-levels sank by about 2.5 metres on the lakes of Bienne, Morat and Neuchâtel. Consequently, large portions of prehistoric sites became exposed and could be studied more easily than before. However, very little in the way of research took place over and above the enthusiastic collecting of objects and mapping of the areas where the piles stood. The search for finds led to general plundering of sites and the authorities had to take drastic measures. Large projects were stopped and only small excavations were permitted. Nevertheless, exceptionally good studies were undertaken during this time. For instance E. von Fellenberg was involved with high-quality work on Lake Bienne. He published his discoveries in 1874, even including plan-drawings in his paper. His sketches of the profiles of the trenches, made through three settlements, gave a clear idea of the stratigraphic development.

In the city of Zurich it was the dredging works in the 1880s, which led to a renewed interest in the lake-dwellings. The work was undertaken at Zürich-Wollishofen and it was done in order to obtain more material for the new embankments being built at that time. Unfortunately, 'the father of lake-dwellings', Ferdinand Keller, did not live long enough to see the wealth of finds discovered on the site. He died in 1881. The number of finds recovered from the dredges was considerable. Surprisingly enough, the majority was only slightly damaged. Amongst the finds there were ceramic vessels, an unusually diverse assortment of weapons, tools and ornaments made of bronze, e.g. swords, anvils and pins. A report (*Pfahlbaubericht*) on the discoveries at Wollishofen was published by the Antiquarian Society of Zurich. This illustrated publication by J. Heierli, who was later to become Senior Lecturer in Prehistory at the Technical University of the Swiss Federation as well as at the University of Zurich, was finally made available to archaeologists all over the world (Heierli 1886).

The study of prehistory made enormous progress in the whole of Europe during the couple of decades after the publication of the first *Pfahlbaubericht*, and the discoveries in the lakes of the Alpine foreland had contributed greatly to this step forward. The Swiss researchers had gradually learnt to see the differences between the Neolithic lake-dwellings and those from the Bronze Age. Chronology became the major topic of research. Moreover, thanks to the large quantity of organic remains (plants and bones) recovered from the sites, scholars had, by then, a fairly clear idea about the economy and subsistence of those lacustrine groups. The book entitled *Urgeschichte der Schweiz* (Prehistory of Switzerland), published by J. Heierli at the turn of the century, gave a good general description of the stage of research (Heierli 1901). The studies concerned with the construction techniques, however, did not progress so well. Archaeologists were more interested in the study of artefacts. The excavation techniques of the time were not advanced and it was difficult to obtain reliable results. The most significant impediment, however, was the fact that most of the sites were under water.

On the other hand, information about ground-plans and floor constructions of houses found in bog settlements inland was not rare. A good example is the exceedingly well-documented excavation undertaken by Johannes Meyer in the settlement Schötz I at Wauwilermoos, Canton Lucerne, between 1908 and 1912.

In 1916, the 'Landesmuseum in Zürich' (the National Museum of Switzerland) started an excavation at the Late Bronze Age settlement of Alpenquai. The two well-preserved cultural layers were unusually thick and the number of the artefacts discovered exceeded all expectations. The finds from Alpenquai are still one of the most important components of the prehistoric department of the museum, though they were analysed and studied in greater detail only quite recently. The survey and excavations made by the Archaeological Diving Team of the City of Zurich, in the 1970s, and recently show that the old assumptions about the location of the houses and their construction, that were rather flimsy to start with, must now be rejected.

Lake-dwellings – an untenable theory?

After half a century of research on lake-dwellings, most archaeologists were totally convinced that the underwater remains represented villages that had once really stood in water. Geologists and biologists, however, maintained that it was unthinkable that the water levels of the lakes could have remained stable for long periods. There was the possibility that the villages could originally have been built on dry shores.

The discussion as to the construction and location of the lake-dwellings only began after the German archaeologist Hans Reinerth published his studies on the settlements of Sipplingen (1921) and that of Unteruhldingen (1929), both on Lake Constance. Reinerth's argument was a sort of compromise. He argued that the houses must have stood on relatively low piles in areas that were subject to seasonal or periodical flooding. He presumed that the water level of the lake had once been much lower, but he did not consider the possibility that the houses could have been built on dry land. Reinerth's impressively large excavations on Lake Constance and later on the Federseemoor caused Swiss archaeologists to take a new perspective on the lake settlements too. However, several archaeologists and biologists challenged Reinerth's theory almost immediately and so it remained only an inspiring idea and did not constitute a serious turning point in archaeological investigations. It is possible that the reason for this may lie in certain rather reprehensible stands Reinerth took during the National-Socialistic Era in Germany. However, if we consider Reinerth's studies more carefully, it becomes obvious that he never actually analysed the results of his excavations in detail, nor did he present enough scientific evidence to support his hypotheses.

Two publications by Emil Vogt, the acknowledged master prehistorian of Switzerland in the 1950s, finally gave rise to the more general rejection of the old ideas regarding the pile dwellings and initiated new discussions about the conflicting pieces of evidence. He had published a report on his excavation of the Neolithic settlement on Egolzwiler Moos, Canton Lucerne, where he had discovered hearths built not on layers of peat but, quite unusually, directly on lake marl, i.e. on the material on which the cultural layers of the pile dwellings normally lay. He had, moreover, discovered that the people who lived at the settlement Egolzwil 3 had covered broad tracts of ground with tree bark – obviously to make it easier to move about in the village. An epoch-making publication, a collection of articles called '*Das Pfahlbauproblem*' was published in 1955. In his pioneering contribution Vogt pointed out that it was usual that only the lower parts of the piles were preserved. He therefore concluded that what had once been believed to be contemporaneous piles represented, in fact, remains of settlements that had often been rebuilt and dated from different epochs. Vogt compared for instance the lenticular clay deposits at the presumed lake-dwelling settlements with the hearths of the Iron Age lake village of Glastonbury in England. There, too, old hearths had sunk in the soft ground and new ones were built immediately on top. Vogt's conclusions were supported by other scholars in the majority of the articles published in *Das Pfahlbauproblem* (Guyan 1955).

Josef Speck also argued for houses built on lake marl in his report on the excavation in Zug-Sumpf, Canton Zug, published in 1952/3. The log structures that he interpreted as remains of log cabins, discovered in the younger cultural layer, seemed a particularly convincing piece of evidence for buildings erected on dry land. The evidence was carefully re-studied in 1996, and it was again concluded that the fundaments in question were definitely laid on dry land (Hochuli *et al*. 1998). These views are, however, still questionable as I shall establish at the end of this chapter. Even Speck himself thought it possible that the houses in question may have had raised floors.

Often the archaeological excavations have promoted cooperation between archaeologists and developers. For example at Auvernier, on Lake Neuchâtel and at Zürich-Seefeld (Utoquai-Färberstrasse). These two sites were discovered and excavated as a result of road and building construction. The contractors even funded the archaeological research. The results were again clear at these sites.

The lenticular forms of the clay deposits observed in the sections could be regarded only as remains of hearths. Furthermore, the excavations supported the assertion that these Late Neolithic settlements stood on shores. The excavations at Auvernier and Zurich provided, definite evidence for the thesis that the settlements, even at the large lakes with markedly different water levels in summer and in winter, did not stand in the water.

The underwater campaign undertaken by divers at 'Kleiner Hafner', a small shoal in the Lake of Zurich in 1966/7, was one of the turning points in the history of lake-dwelling research (Ruoff 1972). In the previous years, techniques were developed to keep the water clear during the excavation. As a result, a proper field excavation could be conducted under water for the first time. This first excavation, as well as the further excavations conducted at 'Kleiner Hafner', revealed a totally unexpected stratigraphy. There were five main cultural layers that dated from *c*. 4500 to *c*. 900 BC, separated by thick layers of lake marl. Each cultural layer was composed of many alternating strata of detritus-rich material, clay and sometimes thin deposits of sand or charcoal (Figure 1.2). These strata

Figure 1.2 The underwater excavation at Kleiner-Hafner in Zurich in winter 1967–1968. The clearly visible dark strata in the left/right profile of the excavated area represent the two cultural layers of the Horgen Culture, *c.* 3000 BC. The lake marl strata accumulated when the area was covered by water. The slanting layers and piles indicate that the ground was not firm and that the strata had slid towards the depths of the lake. Photograph: Büro für Archäologie der Stadt Zürich.

were clearly occupation layers. Sometimes people had abandoned and reoccupied the site after an inundation, making minor repairs to the houses. At other times the whole settlement had been replanned and rebuilt completely. A clear sequence of the layers survived in its entirety, but only along the sides of the shoal, because here the sediment layers had sunk and slipped down, escaping the reach of dredge-shovels and wave erosion. The piles that stood askew, bent or completely broken showed that the subsoil must have started to sink and slide during the Neolithic or the Bronze Age.

Sensational wheels and regularly built villages

As a result of building projects, further prehistoric settlements were discovered in the Seefeld quarter of Zürich-Pressehaus and Zürich-Akad in 1976 and 1978 (Ruoff 1981). An axle and three wooden wheels were discovered at the edge of a village surrounded by a palisade. Each wheel was made from two boards. The village dates from *c.* 2700 BC, i.e. from the Corded Ware Period, thus, the wheels were some of the earliest examples from Central Europe. A wheel made from one board was discovered in an earlier cultural level at a neighbouring site, two years later. This is, so far, the oldest evidence for vehicles from the whole of Europe, and dates to approximately 3150 BC.

All the settlements discovered at Seefeld were regular in layout. Two parallel rows of piles which led through an opening between the palisades and into the open countryside were almost certainly the remains of a trackway, as Vogt had suggested on the basis of similar rows of piles observed at other lake-dwelling sites. The extent of the Corded Ware village and other earlier settlements could be determined accurately only in 1986/8, when new drain-pipes were laid under the streets of Seefeld and archaeologists could conduct rescue excavations. It seems that the Corded Ware village must have been at least 15,000 square metres in extent.

Research techniques developed recently have enabled much better and extensive analyses of the large number of finds, piles and samples from the different layers which numerous rescue excavations brought to light in the last quarter of the twentieth century. Computerization has helped to manage the enormous quantity of data. dendrochronological dates (the first laboratory for Dendrochronology in Switzerland was established in Zurich in 1970) revolutionized the chronology of the late Neolithic and Bronze Age in Central Europe. In many cases this dating technique proved to be the only means of distinguishing between the individual settlements, for there were only a few decades of occupation between some of them.

Today we are no longer surprised by the regular layouts of the prehistoric villages, with their numerous houses standing side by side in straight rows. Quite a number of such settlements, e.g. at Twann, Canton Bern, and around Neuchâtel, were discovered in connection with the large-scale rescue excavations undertaken when new motorways and railways were built along the shores of Lake Bienne and Neuchâtel (Egloff 1989). The regular patterns of the settlements were discernible even in the aerial photographs taken before the excavations were started (Figure 1.3). However, dendrochronological analyses repeatedly show that the history of their construction is always more complicated than the regularity of their plans would lead us to believe. The various houses in a village were built in different stages, often over a short period of time.

It is quite common that fences or even a system of palisades, as at the above-mentioned site of Zürich-Pressehaus, were built around Neolithic and Bronze Age villages. A path or a road leading to the entrance was often constructed too. A fine example of such a road was discovered during the rescue excavations at Concise, Canton Vaud, on Lake Neuchâtel, in 1995/2000 (Wolf 1999). Another impressive roadway, over 100 metres long, was recently excavated in a Late Neolithic settlement at Marin-Les Piécettes, Canton Neuchâtel (Honegger 2001). The road cut through the village and skirted an artificially built mound in the centre. This mound was surmounted by a large, long building, probably erected for some special function. The mound was constructed from a 20–30-centimetre thick layer of clay and gravel. Rows of piles edged it on both sides, but they probably represented remains of an earlier track or perhaps fences. Traces of four inundations were found in the village itself, and the archaeologists consider it possible that the houses stood on piles and that the settlement was planned in such a way that occasional inundations did not cause inconvenience.

And yet there were lake-dwellings too

Discussions about the lake-dwelling theory were now a matter of the past. Villages were built on dry land and there was now enough evidence to prove it. Another large Early Bronze Age 'floor' that cannot have been built in water was discovered at Zürich-Mozartstrasse, 2.5 metres below the present water level of Lake Zurich (Stöckli *et al.* 1995). It was constructed from stocks laid side by side in parallel rows that lay on a foundation of trunks and branches laid crosswise over each other. These were superimposed on perforated base-plates of post-framed buildings of two previous settlements that cannot have stood in water either (Figure 1.4).

And yet, at more and more excavations in Switzerland as well as in other countries, pieces of evidence were discovered that could not be reconciled with the idea of houses standing on dry shores. This was particularly true of the Bronze Age settlements of Fiavé, discovered in the peat bogs of the former Lake Carera in the Trentino region of northern Italy. It was self-evident that all the buildings of one village stood in water.

Pieces of evidence have been discovered here and there during recent excavations that seem to give unmistakable support to the above views. Traces of inundations are common and the example of the above-mentioned Marins-Les Piécettes is particularly effective. A last convincing example comes from the submerged Late Bronze Age Village of Böschen on Lake Greifen (Ruoff 1998). The area was excavated over a ten-year period, and remains of log foundations for 24 buildings were discovered. In some cases there were still five logs on top of

Figure 1.3 Aerial view of the Late Bronze Age settlement/village of Cortaillod on Lake Neuchâtel during the underwater excavation in 1982. The regular, rectangular structure of the piles within an area enclosed by a fence is clearly visible in the photograph. Photograph: Service et Musée d'archéologie de Neuchâtel.

Figure 1.4 The 1981–1982 excavation of the Neolithic and Bronze Age villages of Zürich-Mozartstrasse (the two villages are superimposed upon each other). The wooden sleepers and posts of a long house with several rooms stand directly on the lake marl and date from the seventeenth century BC. Photograph: Büro für Archäologie der Stadt Zürich.

each other, *in situ*. It was surprising that the four bottom logs and also the perforated base-plates placed diagonally under the corners of the rectangular frames had been either bound together or secured, sometimes by mortise or with wooden nails. Bronze Age builders had subsequently driven stabilizing-poles into the ground through the holes made in the corners. This construction technique can only mean one thing. The frames were floated to the site and gradually lowered down to the bottom of the lake weighted by new logs. These houses were probably real lake-dwellings and the village seems to have stood in water until it was destroyed by a fire (Figure 1.5). The study of the village of Böschen

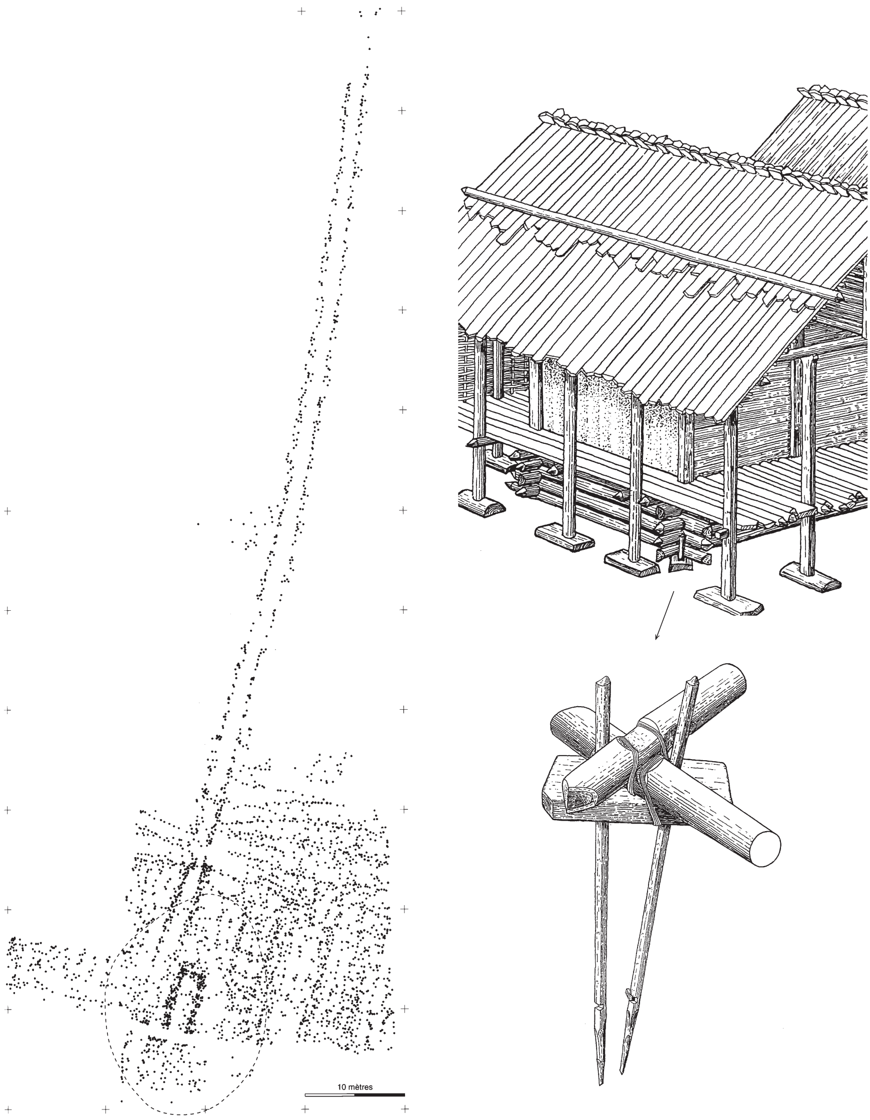

Figure 1.5 Left: the Late Neolithic settlement of Marin-Les Piécettes, Canton Neuchâtel. The long straight road visible between the rows of the piles leads to the settlement surrounded by palisades. In the middle of it there are remains of a building standing on an artificial mound. Drawing: Service et Musée d'archéologie de Neuchâtel. Right: a tentative reconstruction of a house at the Late Bronze Age (1047 BC) settlement of Greifensee-Böschen, Canton Zurich, plus a detailed drawing of the construction technique of one of the buildings discovered during the underwater excavations in the 1990s. Drawing: Büro für Archäologie der Stadt Zürich.

throws new light on the problems presented by the log houses built on the lake marl of Zug-Sumpf on Lake Zug. I am almost certain that the remains of theses houses represent foundations similar to those at Böschen, and thus, the log foundations of Zug-Sumpf might have been built in the water and not on dry land as Speck once argued.

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2

LAKE-DWELLINGS IN SOUTH-WESTERN GERMANY

History of research and contemporary perspectives

Helmut Schlichtherle

Introduction

Unlike the relatively continuous Swiss research on lake-dwellings, settlement of Neolithic and Bronze Age wetland communities on the lakes and fens of south-western Germany has been investigated in three clearly defined stages. Between them lie the two World Wars and several quiet decades. The first two stages have already been widely studied (Kimmig 1981; Smolla 1981; Schöbel 1996; Strobel 2000). An introductory overview will allow us to address crucial questions about these stages, which leads to the current research.

Pioneers

In 1856, Lake Constance came under the influence of the so-called 'stilt village fever' and explorations started there shortly afterwards. Excavation at the Federsee (Lake Feder) followed in 1875. On Lake Constance, work concentrated on the search for wooden house supports in shallow water and on salvaging large amounts of material. No clear settlement structure was established. Meanwhile, complete houses were discovered in the fenlands in Upper Swabia, and walls, floors and hearths were carefully uncovered and recorded. The post-hole evidence was still unknown, and these houses long remained the only clearly rectangular Neolithic constructions in Europe. This site challenged Ferdinand Keller's 'stilt village theory,' which was based on the idea of communal living on a platform built on open water, as these houses had been built at ground level. Scholars did not dare question the stilt village model, although certain evidence might have encouraged them to do so. German archaeologists started to formulate questions about the environment, economy and technology of the inhabitants of prehistoric riverbanks, following the path already taken in Switzerland. Samples were sent to Zurich (Heer 1865) and analysed in Germany. First stratigraphic examinations were made in one of the last campaigns near Bodman and Sipplingen on Lake Constance (Schumacher 1899). A drawback was that the attractive artefacts found on the lakes initiated waves of looting. After a period of chaos, the scientific community finally decided to put an end to this exploitation. Drastic measures were taken and the State of Baden decided to stop all excavations. By the end of the century, research came to a standstill (Schnarrenberger 1891; Tröltsch 1902).

The achievements of these first archaeologists speeded up the discovery of a large number of further settlements and sustained the well-known 'historical' images, which have kept lake-dwelling archaeology so incredibly popular until today. Ancient lifestyles were often presented with scornful humour, belittling the culture portrayed. They were pictured with a fantasy which greatly exceeded the limits set by scientific knowledge yet at the same time archaeologists strove to provide as much detail as possible on excavated objects. The museums were filled with copious finds, but the significance of many would only become apparent as research progressed. On the other hand, the collection of faunal remains and macrobotanical finds had already invoked specialized questioning by specialists in the natural sciences, leading to consideration of settlement's effects on the landscape generally. This was the very first archaeological environmental research.

Professional archaeology

The scene changed dramatically in 1919 when the newly created Institute of Prehistoric Research at Tübingen University started excavations at the Federsee. For the first time, professional archaeologists were at work, and they had a profound impact on the development of archaeological technique. Major influence was exercised by Robert Rudolf Schmidt, founder of the Institute, his student Hans Reinerth and his rival Oskar Paret in Stuttgart.

The Federsee is a shallow lake which has silted up very rapidly. It is situated just to the north of the Alpine foothills. Already drained for peat cutting and reclamation, it was technically ideal for excavation. Five settlements were discovered on the southern side of the marsh. Work began at Aichbühl and Riedschachen, sites known since the nineteenth century, and continued at the newly discovered Neolithic villages near Taubried and Dullenried and the Late Bronze Age Wasserburg Buchau (Schmidt 1930–7; Reinerth 1936). Complete village complexes were uncovered for the first time. They consisted of 10 to 40 houses ordered in rows or loose clusters and sometimes palisaded, accompanied by remains of dugout boats, wagons and plank trackways.

Techniques developed at the Federse were applied to excavations on Lake Constance. In 1929 and 1930, a 22 m × 22 m watertight chamber was built in shallow water near Sipplingen and pumped empty and part of a stilt village was then excavated at the bottom of the lake. The caisson, however, was leaky and results did not correspond with data from the Federsee.

Systematic preparation of photographic mapping and diagrammatic measurements at the Federsee and on Lake Constance was of a very high standard. Further outstanding results were achieved in cooperation with the botanist Karl Betsch, one of the most important pioneers of palynology and macrobotany in south-western Germany. Thanks to the high quality of preserved wood, attempts to date the palisades of the Wasserburg Buchau using dendrochronology were made by the Institute of Forest Botany in Tarant in 1939. This was the first systematic attempt to use this dating method in central European archaeology (Billamboz 2001).

The discovery, in the Federsee fens, of buildings which were constructed on the ground level and the unclear function of some piles on both Lake Constance and Lake Feder led Reinerth to speak of waterfront stilt buildings (*Uferpfahlbauten*) and fen communities (*Moorsiedlungen*) at the same time. This reanimated the discussion of stilt villages. Of central importance was the controversy surrounding the Wasserburg Buchau. Reinerth and Betsch were convinced it stood on an island in the lake, while Paret and the fen geologist Walter Staudacher believed it had been built on the moor, and was cut off later by erosion and rising water. Paret condemned the stilt village theory as a 'romantic illusion' (Paret 1942), and the Swiss research establishment supported him (Guyan 1955). Post-glacial climatic changes were linked with historical events and this was hotly debated (Gams *et al.* 1923). The large-scale approach of German settlement research became the norm and was used by Reinerth in 1932–3 in the Wauwiler Moos, and thus assimilated into Swiss stilt-village archaeology.

The second stage of research in south-western Germany was connected with nationalism as well as national-socialist ideology. The last extensive excavation at the Federsee, which took place in 1937, was supervised by Reinerth, who, by then, had become professor at the University of Berlin and director of the State Association for German Prehistory (*Reichsbund für Deutsche Vorgeschichte*). The study was ideologically biased and linked to political propaganda (Strobel 2000; Schöbel 2002).

Despite the outstanding level of research, the main argument was characterized by both evolutionary and ethnocentric prejudice. Attempts had been made to coordinate the biostratigraphy correctly with settlement during the Neolithic Period, but these were disregarded because results did not 'fit'. The dynamics of the communities themselves, whose findings did indeed indicate different settlement phases, were largely ignored so that an idealized world could be completed. As a result, various stages of chronologically different construction were simply lumped together.

A similar scenario occurred at Sipplingen on Lake Constance. Here too, the replacement of a primitive 'West culture' by migrants from a higher 'Nordic culture' was postulated, by reinterpreting old findings (Keller-Tarnuzzer and Reinerth 1925).

Wetland archaeology started to recover slowly in south-western Germany from 1945 onwards. Settlement studies at the Federsee and on Lake Constance were strongly associated with National Socialism and no one was willing to reopen the debate. Reinerth, who could not return to the university, was limited to minor activity as head of the private open air museum at Unteruhldingen (Schöbel 2001). Meanwhile, Oskar Paret became curator at the Stuttgart Collection of Antiquities and guardian of ancient monuments. He excavated at the newly discovered wetland settlement of Ehrenstein in a valley near Ulm in 1952 (Paret

1955). His work was continued there by Hartwig Zürn (Zürn 1965). At the Federsee a group of natural scientists joined with Ernst Wall, and, very critical of the pre-war data, picked up the research again (Wall 1998). These endeavours are directly connected with current exploration and conservation in the wetlands of Baden-Württemberg.

New energy

In the 1970s a new generation of archaeologists began to study the waterfront and fen communities in south-western Germany (Reim 1975; Schlichtherle and Torke 1976; Schlichtherle 1990a). The Baden-Württemberg Office for the Protection of Ancient Monuments founded the Lake Constance-Upper Swabia Project in 1979 as a response to the renewed interest. Its aim was to record all wetland settlements. Private collections, open country surveys, underwater reconnaissance, measurement and core drilling facilitated the rediscovery of old sites as well as the identification of new ones. Numerous trial trenches were also dug, whose surface was usually not greater than a few square metres. Stratigraphic sampling, core drillings and finds from the surface permitted better understanding of conservation and importance of the settlements. Above all, such samples provided material for scientific dating and bioarchaeological analysis.

The German Research Foundation (Deutsche Forschungsgemeinschaft, DFG) supported seasonal excavations until 1983, in the Upper Swabian wetlands in the summer and on Lake Constance in winter. After that, the DFG started intensive settlement studies in the alpine foothills until 1993. These included the large-scale excavation of the Neolithic site of Hornstaad-Hörnle I on Lake Constance (Figure 2.1) and the Early–Middle Bronze Age settlement of Siedlung Forschner at the Federsee. Dieter Planck, at that time director of Archaeological Monument Conservation, coordinated the projects (Planck *et al.* 1990). Assistance came from Christian Strahm (Institute of Prehistory, Freiburg University) and Erwin Keefer (Württemberg State Museum, Stuttgart) as well as other universities and research institutes. Lake-dwelling research in south-western Germany was greatly strengthened by the establishment on Lake Constance of an underwater archaeology section of the Baden-Württemberg Office for the Protection of Ancient Monuments in Hemmenhofen. Here the laboratories for dendrochronology, archaeobotany, sedimentology and pedology coexist with the archaeological base for underwater and wetland research.

The Lake Constance–Upper Swabia Project, contributed to the discovery of a large number of wetland sites in the Alpine foreland of south-western Germany. About 100 sites were located on the German shore of Lake Constance as opposed to 28 sites on the Swiss shore (Figure 2.2). As is shown by dendrochronological and stratigraphic anayses, most of them were inhabited several times; 15 settlement phases can be demonstrated in the bay of Sipplingen, for example (Schlichtherle and Wahlster 1986). Thirty wetland settlements are known in Upper Swabia and a new area, with well-preserved structures, has recently been discovered in the northern part of the Federsee marsh (Schlichtherle 2002).

Figure 2.1 Excavation near Hornstaad at Lake Constance during wintry low-water levels. Photograph: Landesdenkmalamt Baden-Württemberg.

Cultural groups

The special cultural geography of the richly endowed German alpine foothills is evident from the material found in this region. There is not only close contact with groups in the Swiss area linked to Western Europe, but also to those groups along the Danube and in central Europe (Schlichtherle 1990b). Some finds indicate direct contact over the central Alps to northern Italy, and the Iceman of Hauslabjoch serves as an outstanding and unique example of the alpine crossings which took place regularly long before and after his death (Mottes *et al.* 2002). The area between Lake Constance and central Switzerland is an interesting zone of contact because so many cultures overlap here. The dynamics of these cultural boundaries here present fascinating questions which, research has hardly begun to answer.

New findings as well as further analyses of old material have filled the gaps in the lake-dwelling studies in south-west Germany. New cultural groups have been identified and old ones studied in more detail, including the Aichbühl and Schussenried groups (Lüning *et al*. 1997; Strobel 2000); the Hornstaad (Dieckmann 1985) and Pfyn-Altheim groups of Upper Swabia were more successfully characterized (Schlichtherle 1995a; Mainberger 1998). It was also possible to reconsider the Horgen culture as a whole and isolate a local Horgen

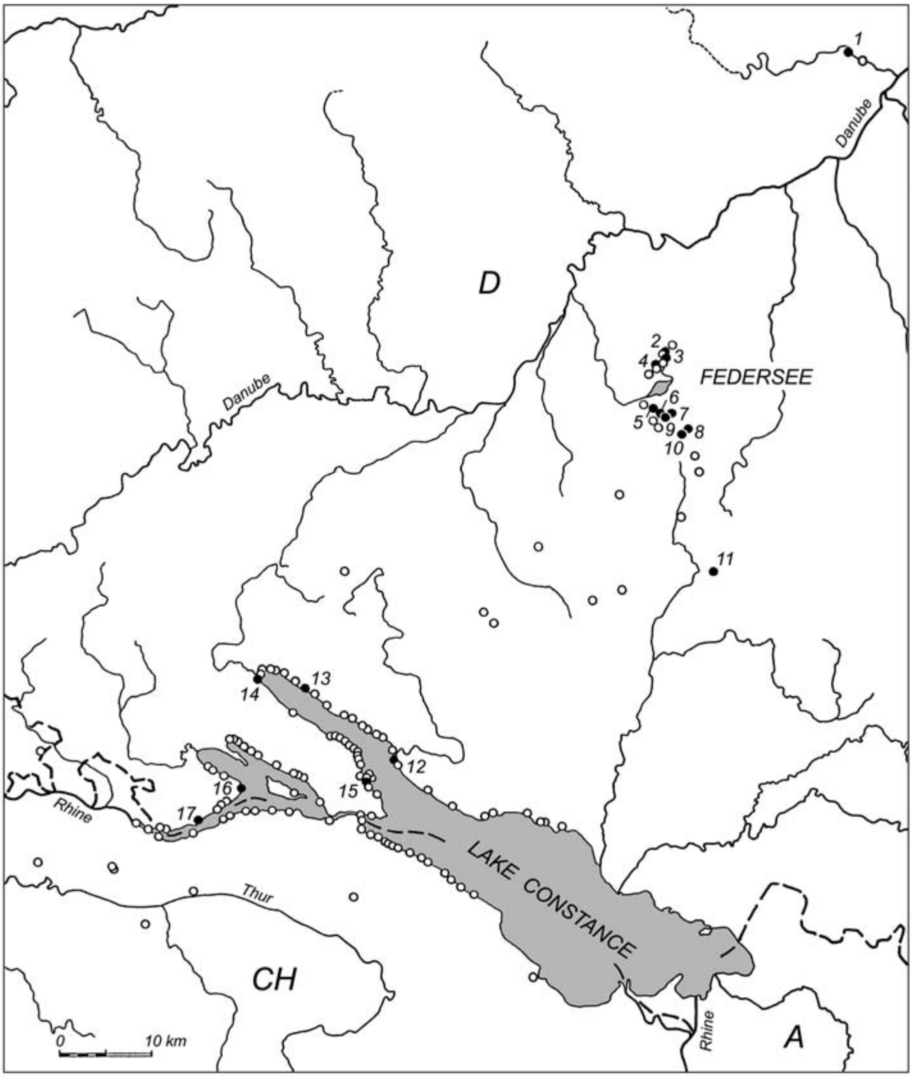

Figure 2.2 Distribution of Neolithic and Bronze Age lake-dwellings between Lake Constance and the Upper Danube. Important sites mentioned in the text: 1 Ehrenstein, 2 Ödenahlen, 3 Seekirch-Stockwiesen, 4 Alleshausen-Grundwiesen, 5 Taubried, 6 Wasserburg Buchau, 7 Oggelshausen-Bruckgraben, 8 Riedschachen, 9 Siedlung Forschner, 10 Aichbühl, 11 Reute-Schorrenried, 12 Unteruhldingen, 13 Sipplingen, 14 Bodman, 15 Egg-Obere Güll, 16 Hornstaad, 17 Wangen. Drawing: A. Kalkowski, Landesdenkmalamt Baden-Württemberg.

group from the Nussdorf-Dullenried type. A better understanding of the Goldberg III group (Schlichtherle and Strobel 1999) and the Early Bronze Age Arbon culture was also achieved (Köninger 1996). We now know that the areas around Lake Constance and in Upper Swabia were culturally fluid. Periods of regional development alternated with periods of inter-regional contact. Thanks to diachronic as well as synchronic studies based on dendrochronology, the south-west German sites are now fully integrated into the Swiss chronology with an accuracy of ± one year (Billamboz 2001).

Houses and settlements

The development of buildings and settlements is now better understood (Figure 2.3) (Schlichtherle 1995b, 1997a). On Lake Constance, water level variations necessitated the use of stilts. In the small lakes and fens of Upper Swabia, construction was level with the ground as well as on wooden posts. Lakeside

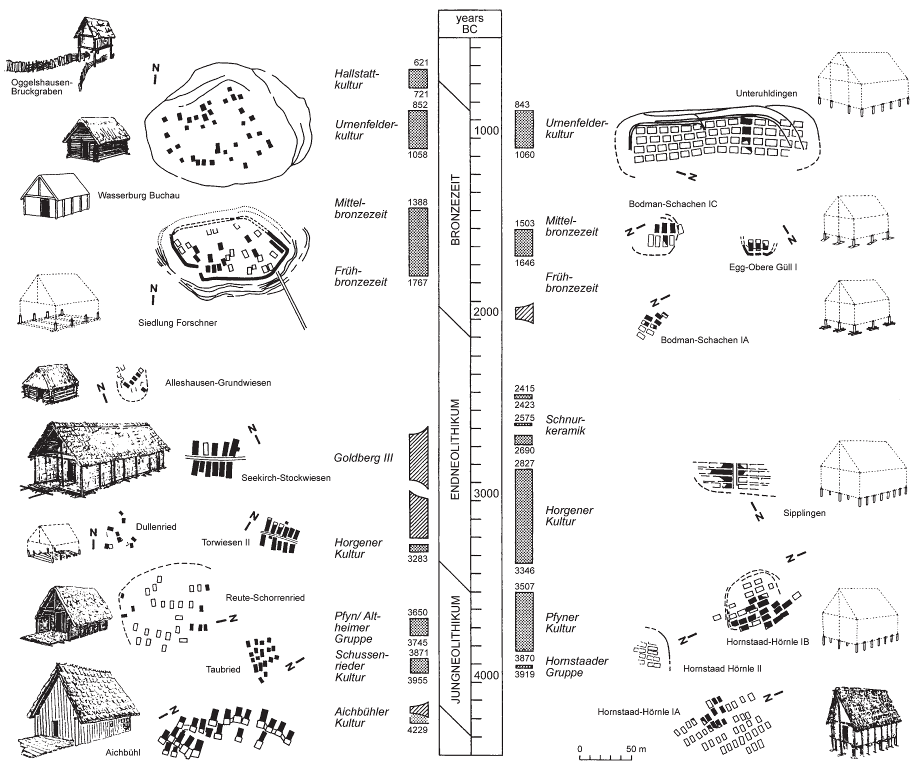

Figure 2.3 Cultural groups in the wetland communities of Upper Swabia (left) and Lake Constance (right). Dating, settlement plans and typical houses. Drawing: A. Kalkowski, Landesdenkmalamt Baden-Württemberg.

dwellings are not easily recognizable; in most cases only the posts and washed-off remains of clay walls, floors and hearths are found. Paleotopography and construction methods have to be ascertained via different methods with each excavation. The first houses (4200–3900 BC) were rectangular in shape and arranged in irregular rows with gables towards the shoreline. In Upper Swabia, the original method was maintained until at least 3650 BC. Around 3500 BC, the lake-dwellings on Lake Constance were erected along a road leading to the waterfront. These kind of 'street villages' also appear at the Federsee about 3300 BC, and the houses, initially laid out in clusters, were also aligned in rows later on. The Bronze Age buildings were constructed in rows on Lake Constance and in clusters at the Federsee. Lacustrine settlements began to be protected by fences around 3850 BC, strong palisades about 3000 BC, or even more complex wooden fortifications, from the Early Bronze Age onwards.

In several places the distribution of ovens and hearths indicates that the late Neolithic buildings were usually single residential units. In Hornstaad unthreshed grain was stored in houses together with implements for agriculture, forestry, hunting, angling and work in the house, making each unit self-sufficient. Annexes or extra buildings were rare. Ground plans of the houses in these Late Neolithic settlements range in number between hamlets of three to eight residential units, to large villages with 40 or more. Little is known about the function of some Bronze Age buildings, but we know for sure that grain was sometimes stored in residential buildings. A Late Bronze Age storehouse has been found at the Wasserburg Buchau. There is no indication of cattle byres in the settlements of Lake Constance, but, occasionally, sheep and goat remains have been found. This suggests that large animals were kept outside of settlements. In Upper Swabia, on the other hand, paleoentomological analysis indicates that livestock was kept within ground level settlements (Schmidt 2004). Detailed study of the functions of certain buildings, portions of settlements or indeed entire villages is a branch of research which has only recently been applied.

Population density

Systematic testing and dendrochronological dating of long timber sequences have revealed very dense settlement patterns. On the shores of Lake Constance there was a settlement every 2.5–5 km during the Neolithic and Bronze Ages. A similar situation is to be found around the Federsee. Construction was dynamic at these settlements; buildings were renovated or rebuilt within a few decades or even years. Central areas shifted and the number of coeval buildings varies greatly, with settlements normally inhabited at intervals of 10–80 years. On Lake Constance, identical locations were resettled after some time, probably as part of agrarian and woodland management systems. Various theories have been proposed assuming short and long circles of shifting cultivation during the Late Neolithic Period with more permanent cultivation towards the end of the Neolithic Period and Bronze Age (Billamboz 2001; Maier and Vogt 2001). New experiments on 'Neolithic' cultivation are still in progress (Rösch *et al.* 2002).

The environment: subsistence and economy

Pollen diagrams have provided new vegetational sequences to the west of Lake Constance and at the Federsee (Liese-Kleiber 1993). Botanical (Rösch 1987; Jacomet 1990; Maier 2004) and zoological (Kokabi 1990) analyses allow identification of staple subsistence resources. Although bioarchaeological evidence in south-west Germany is different and less frequent than that on Lake Zurich (Schibler *et al*. 1997), the development of agriculture and animal husbandry seems to be, in general terms, fairly similar.

The Federsee, however, differs in some aspects. Hunting was more important (Steppan in press) and horses, presumably originally hunted, appear in reasonable number as early as 3700 BC. While farming was the main subsistence activity, some settlements can be characterized as hunting or angling centres. Botanical remains from Alleshausen-Grundwiesen (2800–2400 BC) even show a specialization in flax cultivation and animal husbandry without any sign of the cultivation of cereals. Does this indicate seasonal bases or a more complex system of primary centres with secondary outposts? Lake Constance suggests a waterfront centre in an agrarian environment, but the Federsee wetlands appear to consist of a more marginal area. A major task for lake-dwelling research is to find the extent to which the hinterland around lake villages was settled.

Initially, Neolithic settlements in south-west Germany were exclusively on dry land (Schlichtherle 1990b). Hegau and the Upper Danube lie outside the Lake District and were fairly densely populated during the Early Neolithic and Bronze Ages. Did the lakes and wetlands remain peripheral to primary settlement or did they occasionally develop into primary settlements themselves?

Mesolithic hunters and gatherers 'retreated' to the Alpine lakes towards the fifth millennium BC. Settlements on lakes began earlier in the western Mediterranean Neolithic cultures and they probably represent the origin of Circum Alpine lake-dwellings. Recent macrobotanical analyses show that the staple grain of Neolithic lake-settlers, K*leiner Pfahlbauweizen*, to be *Triticum durum/turgidum*, also cultivated in the Cardial pottery culture of the western Mediterranean (Maier 1998). These people used the same type of harvest knives which characterize the Swiss lake-dwellings (Schlichtherle in press). The strange habit of living on wetlands may be due not to population expansion but to cultural traditions which spread from northern Italian wetlands and along the Rhône valley across Switzerland to southern Germany (Schlichtherle 1995b, 1997b).

Eventually this hypothesis will be tested when more data on the still largely unknown periods before the first lake-dwellings in Switzerland and south-western Germany are discovered. A second stratigraphic deposit containing traces of human occupation from the first half of the fifth millennium BC has recently been obtained from the excavation of deposits in the river Aach near Singen. The study (which is still ongoing) will shed more light on the first lake-dwellers in the Alpine region (Dieckmann *et al*. 2000).

Waterfront settlements were intermittently occupied. Occupation gaps (Final Neolithic, Middle Bronze Age, abrupt Late Urnfield culture end) are more or less simultaneous with Swiss lake-dwellings. Climatic changes have been more or less confirmed by glacial geology and timber analysis (Billamboz 2001; Chapter 8). Dendrochronology, palynology and archaeology show fluctuations in settlement density and the shifting of settlements (sometimes correlating with changing water levels); however, the links between climatic development, changes in water levels and the demography and economy of the south-western German lake-dwellings are still unclear. Analysis of the intricate relationship of natural and cultural history continues to be an important task of interdisciplinary research.

Recent research has identified that technological and economic transitions preceded the radical changes which occurred in the Bronze Age (Figure 2.4). About 3500 BC, flax cultivation increased with textile production, spindles suddenly appeared *en masse* and there was a remarkable increase in the number of pigs. The most important changes, however, are in the spectrum of cultivated plants, accompanying weeds, new harvesting techniques and the systematic use of draught animals – as we see from yokes, disc wheels and archaeozoological finds. Development of the plough and its replacement with the hoe is thought to have occurred during this time (Köninger *et al.* 2001; Köninger *et al.* 2002). Soil studies show the beginning of colluvial deposits. The consequences of this

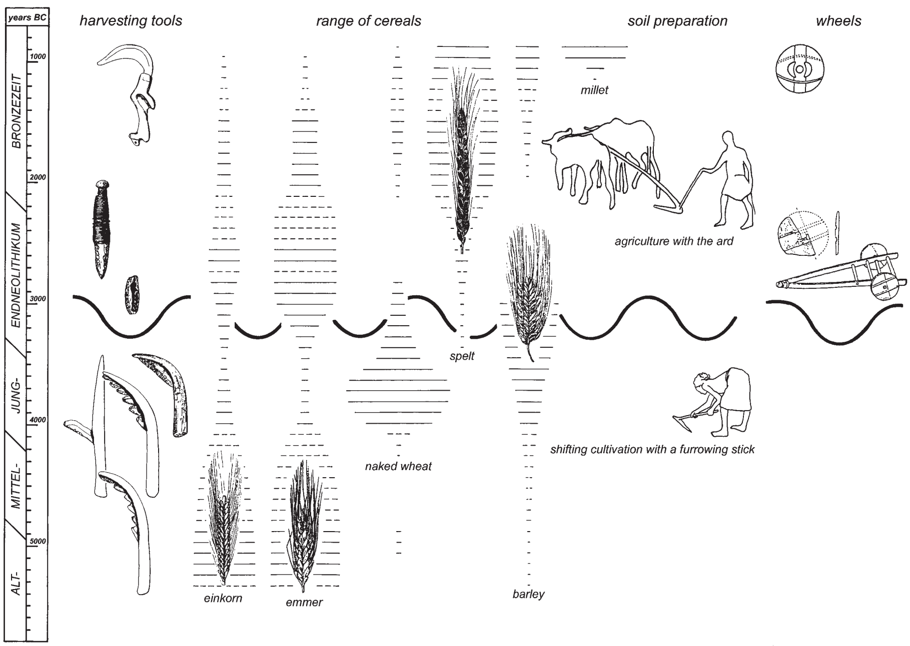

Figure 2.4 Changes in cereals and harvest tools came with the wheel, wagon and draught animals. These finds indicate the introduction of the ard, which does not appear as a substantial find in south-west German lake-dwellings. Drawing: A. Kalkowsky and H. Schlichtherle, Landesdenkmalamt Baden-Württemberg.

restructuring during the Final Neolithic have occasionally been discernible in various places in central Europe. But ancient fenland communities continue to give us the opportunity to study the innovations of the Final Neolithic and the Bronze Age within a degree of detail which can hardly be exceeded.

Conclusions

The third phase of south-western German research on lake-dwellings is in full force. Even though most of the questions addressed here demand further attention, it is important to accept how much has been accomplished since the days of confused chronologies, simplistic migration theories and ethnic quandaries. The relevance of environmental and economic archaeology continues and the vacillations of climate and water levels remain basic constituents to any argument. More attention is now given to links between natural history, technological innovation and cultural development, today increasingly considered in terms of polythetic cultural models. If we can combine all the knowledge which is being gathered at all points on the web of research stretching across the alpine fenlands, we will have a marvellous chance to understand settlement from the Neolithic Period until the end of the Bronze Age in excellent detail.

Translated by Eileen Stemmler-Mohring.

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3

LAKE-DWELLING RESEARCH IN FRANCE

From climate to demography

Pierre Pétrequin and Maxence Bailly

Introduction

For a long period of time, the theory proposed by Keller in 1854 dominated the interpretation of prehistoric lakeside and wetland habitats in France, and for that matter, north-west of the Alps. The idea of villages built on the water was the reward for understanding the exceptionally well-preserved remains in humid or aquatic environments, at a time when it was still believed that there had been no climatic changes during the last several millennia and that it was possible to use the ethnographic examples obtained from the literature of colonial movements. Barely two years after Keller's publication, the first Bronze Age lakeside villages were discovered on the submerged banks of Lake Bourget (Savoie). New discoveries followed in rapid succession. In 1860, on the southern shore of Lake Geneva (Léman) (Haute-Savoie), following the work of Troyon and Forel; in the same year on Lake Annecy (Haute-Savoie) at the site of Roselet; in 1870, at Clairvaux-les-Lacs (Jura), with the first Neolithic lakeside village; in 1903, at Aiguebelette (Savoie); in 1904 at Fontenu (Jura) on Lake Chalain and finally, at Charavines (Isère) at the site of Les Baigneurs.

A century later, these same lakes were still the subject of prospecting and excavations. The research expanded outside the Circum-Alpine region to other glacier lakes too, however, to complete the approximate mapping of the lakeside phenomenon which impacts on the entire periphery of the Alps, we need to mention some less well-known sites. These are: the peat-bogs of Thuellin and Passins (Isère), the sites of Châtelneuf on Lake Fioget and La Chaux-du-Dombief on Lake Ilay (Jura), and finally, the peat-bog of Villeneuve d'Amont (Doubs).

From the pile dwelling to the low-water-level lakeside village

The initial period of wetlands research in France started in 1860 with the discovery of the sites of Lake Bourget and ended with the first archaeological contextualization of the lakeside dwellings in the Jura, by Piroutet, in 1929. During this time-period, the lakeside dwellings were treated as a treasur trove of archaeological artefacts, where collectors and museum curators went to retrieve rare objects in surprisingly large quantities. These objects consisted of tools, weapons, wooden objects, cloth, wickerwork, and even seeds preserved by the hundreds of thousand in the waterlogged sediments. This remarkable hotchpotch of archaeological objects, from which everyday life could be discerned in detail, was exploited with little regard for chronology, particularly since at that time (and until recently), the Neolithic and Proto-historic periods in France were rather neglected in comparison to earlier periods. The image proposed by Keller, with houses built on floating platforms, an industrious population and its devastating wars, was for a long time sufficient for the scientific community and the wider public and stimulated interest in later prehistoric times, since it evoked some of the greatest moments brought back from the overseas colonies and the 'la Grande France'.

The declaration of war in 1914 sounded a knell for French prehistoric archaeology. Whilst Swiss prehistoric studies were feeding the national image of a primitive Switzerland with its lake communities set against a backdrop of snow-capped Alps, the dynamism of research was gathering pace in south-west Germany. In the region of Federsee, Schmidt was beginning to uncover large areas with villages made of rectangular buildings, built directly on the ground, which caused interpretative problems, contradicting the dominant theories of the time. Between the wars, Reinerth continued this work to the greater glory of a Nationalistic Germany with European aspirations, which inscribed archaeology in its propaganda.

Little of either this German research or that of the Swiss, which, following the lead of Reinerth, was being developed during the 1950s and 1960s in the central and northern regions of their country, filtered into French scientific circles. French scholars were seemingly not interested in wetland archaeology. The first seed was sown by the publication of Vogt's *Pfahlbaustudien*, in which he reviewed the issue of houses built on pilings, demonstrating that the water level of the lakes had varied over time and that the houses had been built on dry land during periods of low water. The idea in itself was not new, but it was the pamphlet published in French by Paret in 1958 which turned the tables in France. The myth of the 'lake communities' was subsequently abandoned without further ado, and the ideas expressed by Reinerth were passed over in silence.

We can therefore consider that during the 1960s and 1970s, the international scientific community accepted the new theories, moving from one interpretative extreme to another; the only small doubting voice being that of Strahm, concerning Yverdon – Av. des Sports (canton Vaud). For everyone else, the issue was now settled: during periods of low water, the Neolithic and Bronze Age agriculturalists built houses at ground level on the exposed shoreline and in the bogs. These recently emerged lands were particularly hospitable, being close to expanses of water rich in fish. With the return of more humid conditions, the rising water table drove the inhabitants towards dry land.

Abandoning the ethnographic and comparative viewpoint (which went out of fashion during the process of decolonization), we present here a simple interpretative model which answers all the questions regarding the reasons for and methods of establishing villages on wetlands.

Return to the sites

Almost all the pioneering research was set in motion by drainage works on the bogs and the lowering of the water tables and such conditions, easy for excavation, no longer exist in France. The water tables have been stabilized since the beginning of the nineteenth century and most of the sites are now submerged. This does not necessarily prevent their erosion and rapid degradation.

The first return to archaeological excavations was initiated by scuba diving, and in particular by the survey of the Late Bronze Age villages on Lake Bourget, led by Laurent during the 1960s (Bocquet and Houot 1994). Although barely mentioned in publications, these methodological improvements supplied some essential clues as to how to tackle underwater sites using up-to-date archaeological methods.

The movement gathered pace with the setting-up of Regional Archaeological Services, which initiated surveys and excavations throughout France. Starting in 1970, a long-term research project on the Neolithic of the Central Jura was under way at Clairvaux, and it was followed by Chalain (Pétrequin 1997). Next came the extensive dig of the late Neolithic village of Charavines (Isère), Les Baigneurs, on the shore of Lake Paladru, during 1972 to 1976 (Bocquet and Houot 1994). The underwater survey of the bed of the River Saône at Ouroux-sur-Saône was followed by Chalon-sur-Saône (Saône-et-Loire), Le Gué des Piles, from 1974 to 1989, with the first villages of the Late Bronze Age, built on the secondary bed of a river (Bonnamour 1989). As for the lakes of Bourget, Annecy, Aiguebelette and Geneva (Léman) in the foothills of the Alps, they have been the object of regular prospecting, mapping and test borings since 1983 (Billaud and Marguet 1999). From the Jura to the northern Alps research was in full swing, whilst in France, where evidence was not lacking, fieldwork was rare and insubstantial with the exception of the Late Bronze Age site on the salt pond of Thau (Hérault), which is still under investigation (Leroy 2000).

At present we are therefore still dealing with strictly regional research. Complex archaeological techniques and the specificity of the archaeological sediments make underwater and wetland research a particular type of archaeology. There are even instances in other regions where there is a lack of understanding on how to treat this first-rate archaeological evidence, as demonstrated by the case of the building of the canal of Brivet across the bog of la Grande Brière (Loire-Atlantique).

We are thus faced with a paradoxical situation. A specific natural environment particularly poorly understood by archaeologists, and the highly specialized form of excavation, which fails to attract prehistorians from outside the Alpine-Jurassic arc. At the same time, specialists in archaeometry and the natural sciences are pressing forward to develop new research and interpretative methods in these environments where the conservation of matter is remarkably good. Furthermore, the notion that these wetland sites are exceptional and need to be treated as such is a long way from being acknowledged in France. Fortunately, to eliminate the risk of destruction, the marshes that border the lakes of Clairvaux and Chalain have been registered in the Supplementary Inventory of Historical Monuments and thus physically protected from erosion and desiccation. This is at present unique.

Towards other interpretations of the shore-side habitats

By encouraging an increasing number of fieldwork programmes and scientific research projects over the past 32 years, the Centre National de la Recherche Scientifique and the Sous-Direction de l'Archéologie have made the lakes of Chalain and Clairvaux outstanding case-studies of French prehistory. The originality of this work does not lie either in the time periods covered (approximately equal to those of western Switzerland, with periods of occupation and abandonment stretching from 3900 BC to 850 BC (Giligny *et al.* 1995), or in the better preservation of the archaeological remains, but in the total absence of any urgency in undertaking the research. This has allowed archaeologists to approach the subject from three important perspectives: engagement with long-term research, which permits the accumulation of observations and their critique; a regional approach, allowing the lakeside habitat to be considered in a larger environmental and social context; and finally, an ethnoarchaeological approach where archaeological models were based on ethnoarchaeological observations. This process has been gradually instigated over the last decade, since it became apparent that the interpretations proposed to date, particularly those put forward by Vogt (1955) and Paret (1958), did not allow archaeologists to assess all known data.

The research programme (Pétrequin 1984) in fact calls for radically different concepts, such as that relating to architectural adaptations (Pétrequin and Pétrequin 1984; Pétrequin 1991; Nicoud 1992) and the variations in population density (Pétrequin *et al.* 2002), in an attempt to explain the adaptation of certain agricultural communities to wetland sites and grasp the cycles of habitation, dominated principally by climatic change.

A defensive habitat

The primary, but essential, question is why hamlets and villages were built in the middle of marshes, or on the edge of lakes, on beaches made of lake chalk, more or less above water level, soft underfoot, permanently damp and subject to regular flooding. The so-called ease of building, or else the plentiful supply of lake fish are arguments that carry little conviction, particularly in the light of Neolithic farmers who spurned fishing on the lake, preferring river trout which they caught in large quantities (Dommelier *et al.* 1998).

The answer to the problem can therefore be sought using other terms of reference: what reasons would incite a group of agriculturalists to build their cereal lofts and their permanent residences in an environment so inhospitable, muddy, unstable and prone to flooding, far from their cornfields, cattle runs and a fair distance from the woodlands which supplied the best timber for construction or firewood (Pétrequin *et al.* 1998)? This choice is not so surprising when considered alongside wider historical and geographic data. It is similar to those which elsewhere led to the selection of ridges or the brow of hills for the erection of fortified villages. On dry land for instance, cliffs and steep hills are natural defences; in the bogs and on the lakeshores, the choice of location rested on the existence of different natural defences: water and a large expanse of marshland on the side of dry land. The similarity between a village established on high ground in the Middle Neolithic (fourth millennium BC), such as Montmorot, Jura (Figure 3.1, top picture) and a contemporary lakeside village, Clairvaux, is too obvious to require lengthy debate (Figure 3.1, bottom picture).

Starting in 3700 BC, the desire for isolation caused architectural changes within the wetland village tradition, for example: houses with raised flooring built on pilings, houses built on foundation frames, in bogs, and with floorings of perpendicularly set crossbeams (Pétrequin 1991). The objective was to built the habitations as far as possible from dry land and to group the largest number of dwellings on the smallest possible space, whether the houses were built parallel to the shore, or the village was structured with dwellings facing each other along its axes (Pétrequin *et al.* 1999). The village of Chalain 19 (Figure 3.2), occupied during the thirty-second and thirty-first centuries, is a fine example of a hamlet of grouped dwellings, enclosed by a sturdy ash and oak palisade which was regularly renewed. A path 1.80 to 2.10 m wide crossed the lakeside depression of soft ground and the bog towards dry land over a distance of 125 m. A sledge drawn by oxen also used this path, alternatively covered with bedding or planking made of slats resting on low supports. We can imagine the considerable effort required both to build and regularly maintain such a thoroughfare over several consecutive decades.

Following the interpretation that lakeside habitats were a variant of the fortified habitat and enclosures on dry land, a more general question can be formulated: when exactly did the fortified Neolithic and Bronze Age habitats develop in the Jura?

Climate and occurrence of habitations: an overview

Comparing the variation curve of the number of lakeside villages in the French Jura (Figure 3.3, graph 2) and that of fortified hilltop villages in the province of Franche-Comté (Figure 3.3, graph 3), during the Middle Neolithic from 3700 to 3400 BC, the correlation between the number of these villages (amongst other types of villages) is surprisingly close. The same correlation appears to exist, if in a less marked form, during the Late Neolithic from 3200 to 2500 BC. In contrast, there appears to be no correlation during the Late Bronze Age: the hilltop sites were frequently not occupied to the very end of the Bronze Age. Instead, this period is characterized by another form of habitat, the temporary cave refuge,

Figure 3.1 Two types of defensive habitat. Top: the hilltop village of the Château at Montmorot (fourth millennium BC) Jura. Below: the site of la Motte-aux-Magnins at Clairvaux-les-Lacs (fourth and third millennia BC), Jura. Photographs: P. Pétrequin.

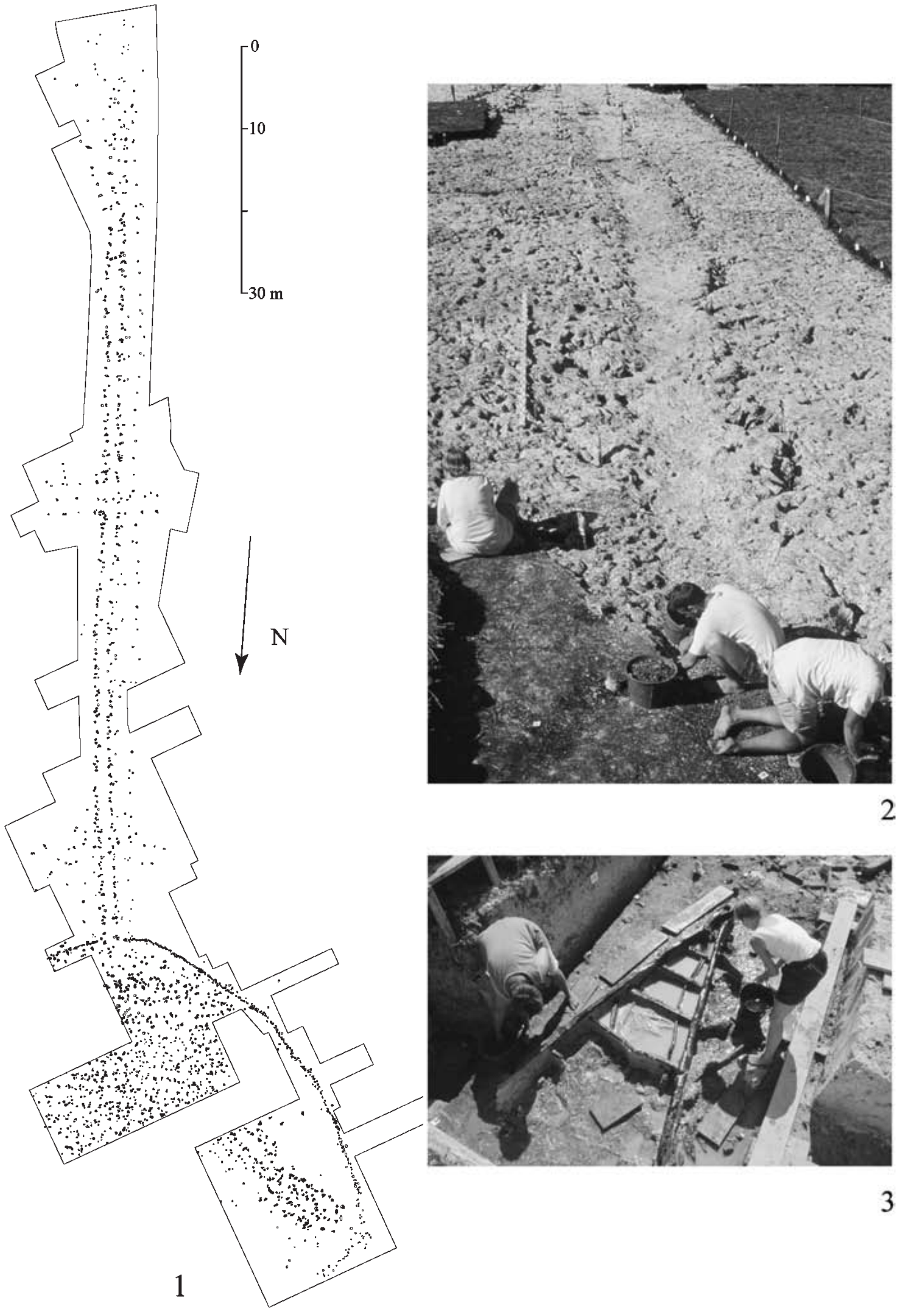

Figure 3.2 The village of Chalain 19 at Fontenu (Jura) with its access path, its palisade and a sledge dated *c.* 3000 BC. Drawing: A. Viellet; photograph: P. Pétrequin.

often contemporaneous with certain valley-floor villages (Pétrequin *et al.* 1985). The correlation between lakeside villages and the temporary cave refuges during the Late Bronze Age IIb-IIIa is perfect (Figure 3.3, graph 4).

The hypothesis that lakeside or wetland villages were built for protective purposes by agricultural communities is therefore valid, when considered in the

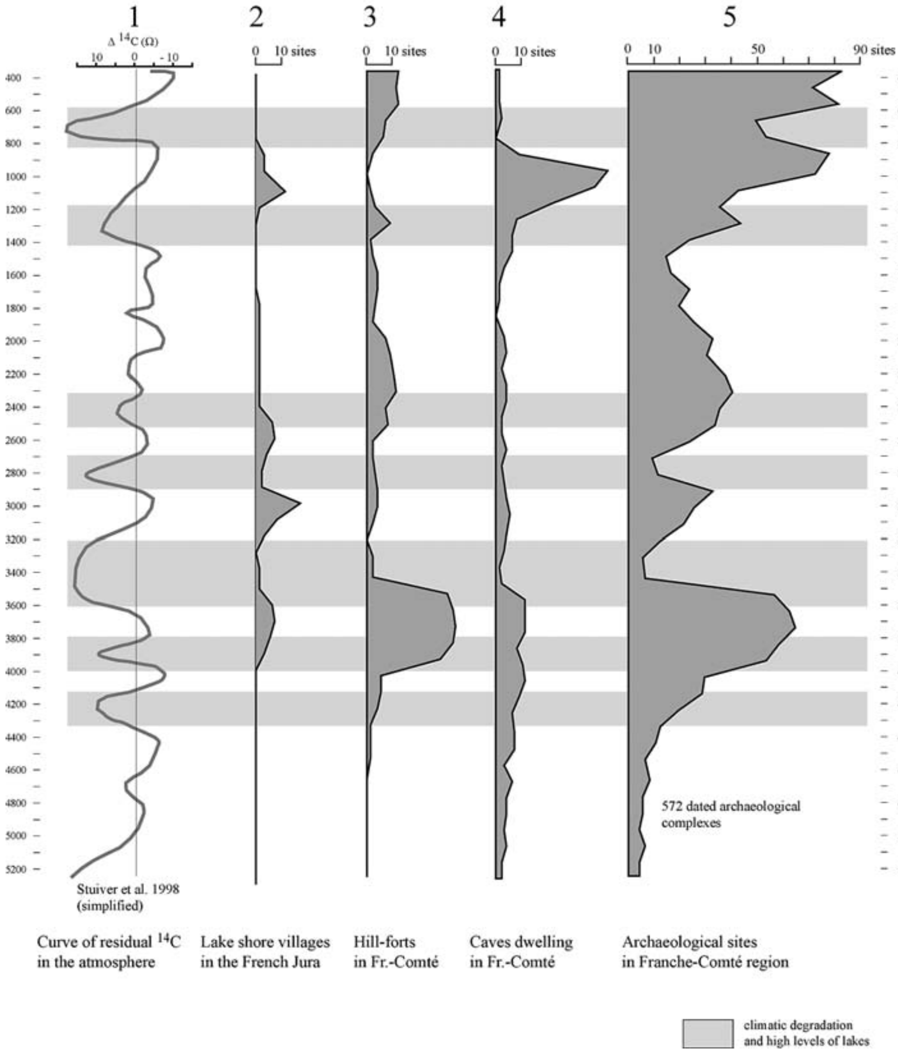

Figure 3.3 Climatic evolution (indirectly illustrated by the ^{14}C atmospheric residual curve) and the variation in the number of archaeological sites in Franche-Comté. Drawing: P. Pétrequin, based on Stuiver *et al.* 1998.

context of the occupation of hilltop fortifications and caves. Under these conditions, the decision to construct settlements in lakes or bogs is evidently a social choice, which the climatic issue and that of the fluctuation in the water level in the lakes are sometimes unable to elucidate.

Magny has studied the sedimentary sequences in the Jura lakes and those of Chalain and Clairvaux in particular, where precise dendrochronological dating is possible, and he has demonstrated that the variations in the water level of the lakes can be closely correlated to climatic variations (Magny 1995). In addition, he has shown that the residual atmospheric radiocarbon curve (Stuiver *et al*. 1998) is an indirect indicator of these climatic changes, and consequently, that of the water level in the lakes. The radiocarbon curve (Figure 3.3, graph 1) shows that, in accordance with the hypothesis of Paret (1958) and of Vogt (1955), the lakeside habitats can largely be dated to the periods of climatic improvements and low water levels; this hypothesis has been successfully tested by comparing Stuiver's curve with all the dendrochronological dates obtained from Neolithic and Bronze Age sites north-west of the Alps (Magny 1993).

Although we can well understand why lakeside villages were mostly occupied during periods when the water level on the lakes was low, it is more difficult to grasp, without taking into consideration social phenomena, the reasons for a low occupancy level of lakeshore sites in the French Jura, during long periods of low water level and favourable climatic conditions, e.g. the periods of the Bell Beaker Folk and the Bronze Age, between 2300 and 1400 BC.

The question of habitat on wetland sites would, therefore, appear to go well beyond a strict relationship and automatic correlation using the hypothesis of climatic conditions. Furthermore, when examining the situation at the regional level of Franche-Comté, the number of dry land sites, between 5500 and 400 BC (based on 572 documented archaeological sites), fluctuated regularly in relation to the most severe and prolonged periods of climatic deterioration (Figure 3.3, graph 5). The number of archaeological sites for the entire region drops dramatically, as those on the lake shores temporarily disappear; between the thirty-fourth and thirty-third centuries, again during the twenty-ninth and twenty-eighth centuries and finally during the eighth century.

It is therefore not possible to minimize either the effect of climatic change or the sociological hypotheses, and this is equally true for dry land and wetland habitats. At this stage it is crucial to consider a partial correlation (direct or indirect) between climatic changes and changes in population density. Such a correlation has already been discussed for the Early Neolithic (Richard and Ruffaldi 1996), and subsequently tested on several occasions against the occupancy level of lake-shore sites in the French Jura (Arbogast *et al.* 1996; Pétrequin 1997).

Variations in population density: a detailed approach

Prehistorians and palynologists, each within their domain, have demonstrated that population growth during the Neolithic and Bronze Age was neither steady nor regular. The sum of regional archaeological sites must, however, always be treated with care and circumspection, and pollen count diagrams are only indirect reflections of population density.

In the cases of Lake Chalain and Lake Clairvaux, the study period spanning from the thirty-second to the twenty-ninth century BC has been intensively addressed, because of the excellent preservation of archaeological remains, the large number of successive or contemporaneous villages and finally, the fact that this lake-shore occupation was sandwiched between two periods of strong climatic degradation (Figure 3.3, graph 1). If a classical approach had been adopted, without considering the chronology in slices of ten years, it would have appeared that the occupation of the lake shores had occurred as soon as the water level had dropped, and their desertion had occurred soon after the climatic degradation and rise of the water level. The hypothesis would have been that the population had moved to dry land, in search of a more favourable habitat. The question is worth exploring since the surveys and excavations around these lakes over the past 30 years have not produced a single dry land site dated to either an earlier or a later period. Furthermore, the pollen count diagrams suggest a wooded environment with no human occupation during the thirty-third century BC and a marked reduction in human activity during the twenty-ninth.

During this period, the lakes of the Central Jura were on the border between the cultural influences of the Horgen and Ferrières cultures (Figure 3.4, 1). Around 3200 BC, Chalain and Clairvaux were colonized by Horgen groups who attacked the forest cover and built four contemporaneous villages. The timber selected for the house posts were long ash poles, which evoke an open forest environment and also shoots growing from stumps, possibly in relation to an itinerant agriculture. Towards 3050 BC, after a short period during which the lake shores were abandoned, these two lakes were again colonized by Ferrières communities. The sudden changes in ceramic and architectural styles as well as in the provenance of raw materials plead in favour of the arrival of small groups of migrants. The number of contemporaneous villages then grows in less than 40 years from five to 15, whilst the timber used for the house foundations was cut from large oak trees, probably drawn from a mature forest environment, possibly even a primary forest. The population had tripled at least, whilst the land cleared for cereal cultivation now stretched well beyond its previous limits. This demographic growth, occurring at the same time as the climatic improvement, had a severe impact on regional forests (Pétrequin *et al.* 1998 and 2002), and local lacustrine groups now had to go even further inland in the search for construction timber and firewood. Finally, around 2950 BC, the population density on the lake shores collapsed and this change occurred well before the first indications of the climatic deterioration of the thirtieth century BC.

This demographic collapse, which also occurred simultaneously in western Switzerland (Wolf and Hurni 2002), could be related to a complete cycle of lake shore occupation. Demographic growth and occupation of the territory, followed by the re-establishment of favourable conditions for the cultivation of cereals, over a wide territory previously unoccupied for two centuries, may have led the

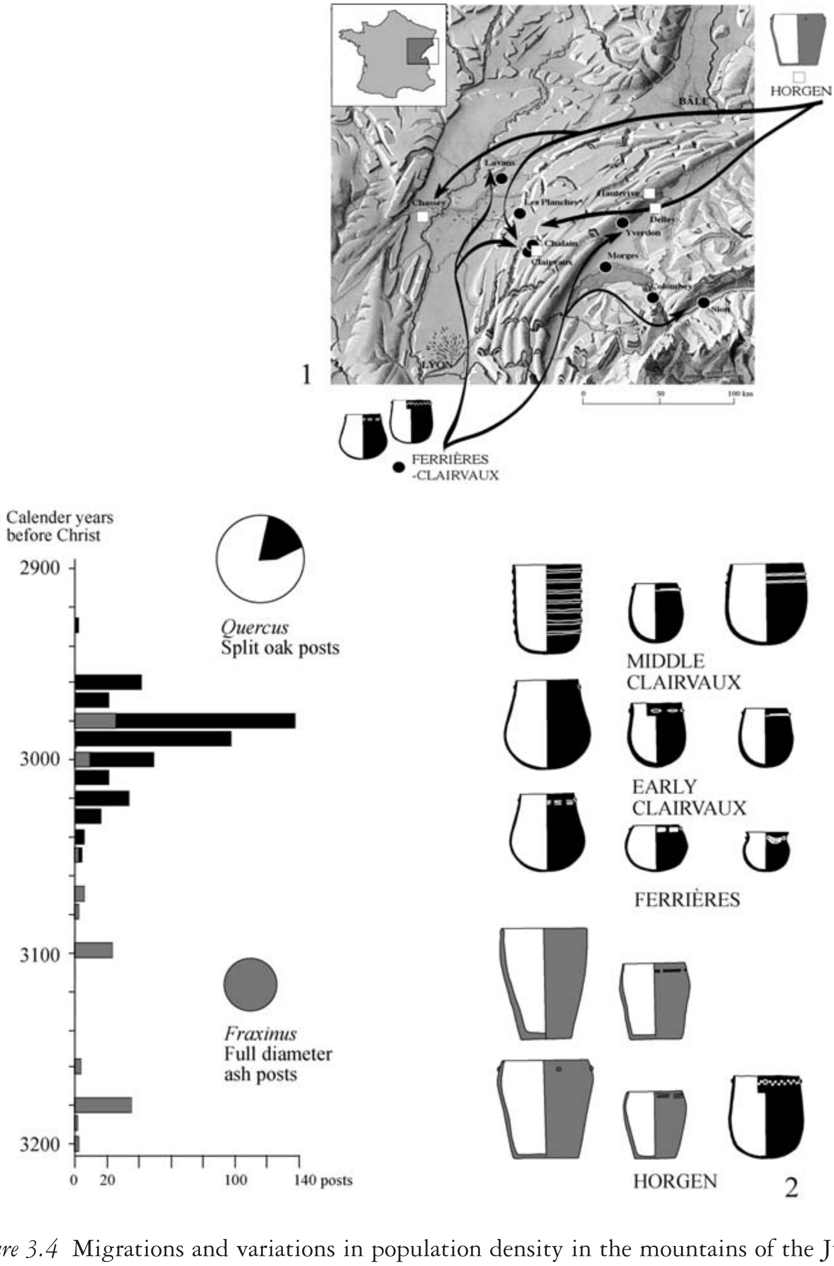

Figure 3.4 Migrations and variations in population density in the mountains of the Jura. 1 The Horgen and Ferrières villages during the thirty-second and twenty-eighth centuries BC. 2 Variations in the supply of architectural timber at Chalain and Clairvaux (Jura), in relation to the evolution of ceramic styles. The sample used for the graph includes only posts that have most of the tree-rings or the last tree-ring before the bark. Drawing: P. Pétrequin and A. Viellet.

local lakeside groups to decide to populate the lake shore, regardless of the unfavourable environment conditions. Following a sequence of several years of bad harvests in relation to poor weather conditions, and reduced ecological balance, economical crises developed, which had a direct influence on the population density (Arbogast *et al.* 1996).

Conclusions

As a concluding remark, we can certainly say that the fluctuation of the lake level is only one aspect which can influence the lakeside habitat and consequently patterns of lacustrine human occupation. Phases of occupation and periods of abandonment are also related to different social responses, not only as far as lake-dwelling groups are concerned, but also the neighbouring dry-land communities. These cultural changes are often reflected by demographic discrepancies. It is therefore in the variation of population density that we need to search for the explanations of the Neolithic lake-shore habitats, just as the Late Bronze Age period was addressed (Pétrequin *et al.* 1985; Brun 1988). This avenue of research may allow scholars to escape from a methodological dead-end, itself the result of favouring unexplained moves back and forth between lake and dry land, without taking into account the statistics based on the archaeological records of dry land.

Translated by Michael Templer.

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4

PREHISTORIC LACUSTRINE VILLAGES ON THE AUSTRIAN LAKES

Past and recent research developments

Elisabeth Ruttkay, Otto Cichocki, Ernst Pernicka and Erich Pucher

Introduction

Prehistoric pile-dwellings are to be found in two Austrian provinces: Upper Austria and Carinthia. In Upper Austria, they are located on the shorelines of three Salzkammergut lakes: Mondsee (Lake Mond), Attersee (Lake Atter) and Traunsee (Lake Traun), and in Carinthia on Keutschacher See (Lake Keutschacher), a small lake south of Wörthersee (Lake Wörther). Settlements with pile-dwellings were confirmed on all the above-mentioned four lakes around the mid-nineteenth century. The first and most unusual settlement was discovered on an island in the middle of Keutschacher See in 1864. Dendro-dating confirmed this settlement as the oldest Neolithic pile-dwelling settlement in Austria. The Salzkammergut lakes produced an unusually high quantity of ceramic and metal finds. In particular, the station See on Mondsee was the focus of continual research interest.

The pile-dwellings in the Salzkammergut lakes

Location and structure of the settlements

About 23 sites on the Salzkammergut lakes have been radiocarbon dated to the fourth millennium BC; two sites (Abtsdorf 1 and Seewalchen 1 on Attersee), to the middle of the second millennium BC; two (Traunkirchen and Gmunden on Traunsee) dated via ceramics to the turn of the second and first millennia BC. Therefore, contrary to assumptions from earlier research, they did not exist continuously. The Bronze Age settlements are less common, and scattered finds including ceramics indicate that these settlements were often far denser than previously surmised. It appears that during the second millennium BC the lake level in Attersee was significantly lower than during the fourth millennium BC, or indeed lower than today's level. Furthermore, the location of the Bronze Age huts seems to have been located in shallower water than those of the Neolithic.

See, for instance, the site of Seewalchen 1 on Attersee, which is located 130 m offshore (Willvonseder 1963–8: 88–9). The settlement at Abtsdorf 1 on Attersee, featuring Early Bronze Age ceramics exclusively, was also found 200 m offshore, as opposed to the neighbouring Neolithic stations of Abtsdorf 2 and Abtsdorf 3, which lie 60 m and 80 m from shore respectively (Czech 1977: 89–94; Czech 1982; Ruttkay 1982). The majority of the pile complexes date to the Neolithic (Figure 4.1). Offenberger directed the documentation of the Austrian lacustrine settlements for the Federal Office of Monument Protection (Bundesdenkmalamt) from 1970 to 1986. He reported that only 13 of the 23 settlements on Attersee had been surveyed and cartographically documented (Offenberger and Ruttkay 1997). On Mondsee, the sites of Schärfling, See and Mooswinkel have also been surveyed, but more recently (Lochner 1997).

Offenberger could not only determine the recurring, similarly situated locations of Neolithic settlements in the landscape, but also the building method of individual huts. The floors of the houses were built on a supporting framework that was fastened into the lake floor with pegs. In some places, it was evident that the floors would only have been raised 20–30 cm. Various combinations of the wooden construction elements found permit a wide variety of possible reconstructions. At three sites (Schärfling, Misling 2 and Weyregg-Landungssteg), the findings permit us to assume that log frameworks, secured into the soil with pegs, served as the foundations of the huts. This foundation structure would compensate for the instability of the lake floor (calcareous mud). Many traverse beams with recesses were found, which indicated rectangular huts with wattlework walls that averaged 3–4 metres in length (Offenberger 1981).

Valuable macrobotanical samples were retrieved by sieving from sediments, during the excavations by the Federal Office of Monument Protection at the settlement of See on Mondsee. Noteworthy was the high proportion of fir. That branches of fir were purposely selected would seem certain. According to botanist Pawlik, it can be argued that the fir branches were used as insulation on hut floors and in the walls (Pawlik 1993).

Unfortunately, despite concerted xylotomical examinations by Cichocki at See on Mondsee, the arrangement of the huts/houses within the settlements has not yet been determined. To date, no sites that were formerly submerged and are now on dry land have been discovered in Austria. Such a site would provide the ideal situation in order to find a solution to this question. Our pile structures lie, with one exception (Mooswinkel on Mondsee), on shelves running offshore submerged under 3–4 m of water. Mooswinkel, at a depth of 8 m, is interpreted as a special case: a ferry landing.

Further organic samples

A particular advantage of the pile-dwelling settlements is the preservation of finds to a degree that is rarely found elsewhere. These are finds of organic substances such as baskets, sacks, wickerwork and fabrics, as well as tools and vessels of wood. Such finds from the Neolithic settlement See on Mondsee (100

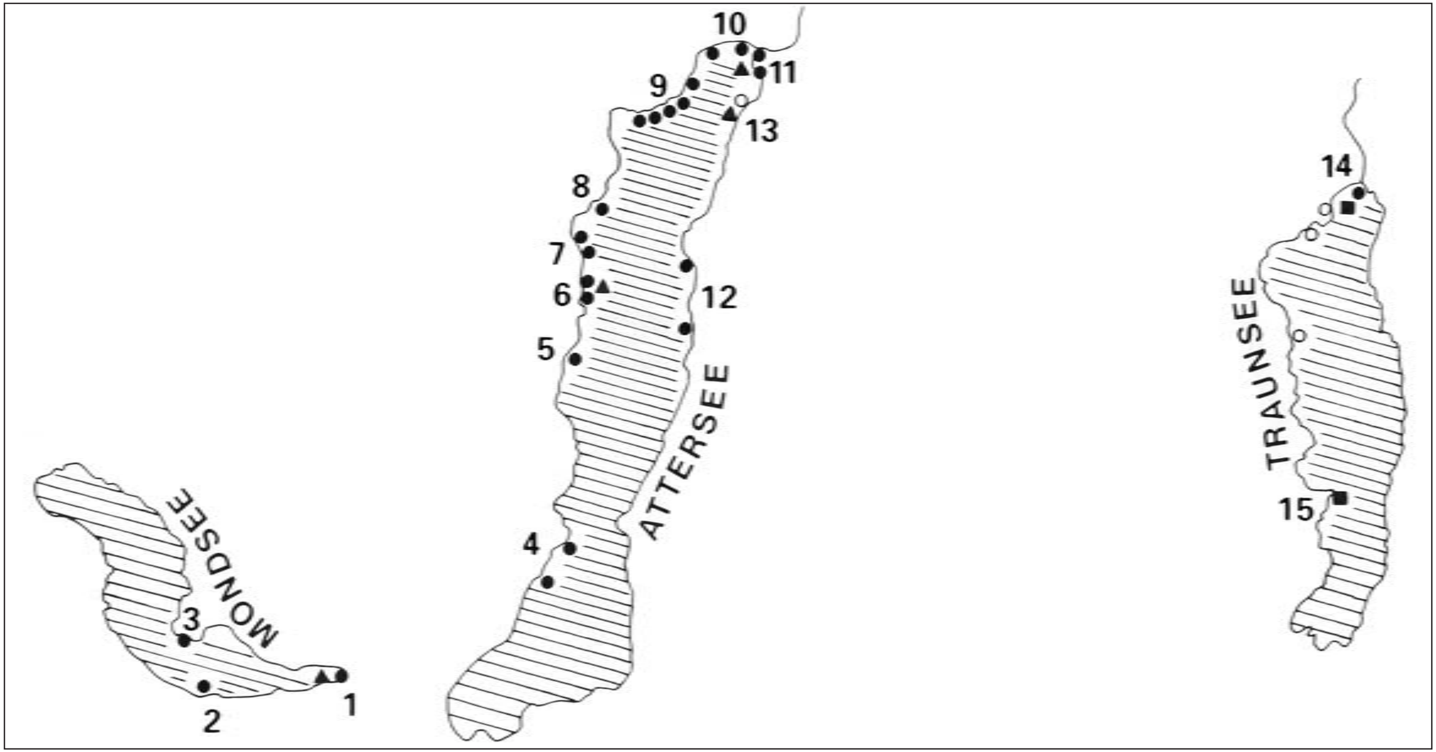

Figure 4.1 Lacustrine settlements on the Salzkammergut lakes, Upper Austria. ● Mondsee group, ▲ Attersee group, ■ late Bronze Age, ○ unsubstantiated. Mondsee: 1 See, Unterach. 2 Schärfling, St. Lorenz. 3 Mooswinkel, Innenschwand. Attersee: 4 Misling, 2 sites. 5 Nussdorf. 6 Abtsdorf, 3 sites. 7 Aufham, 2 sites. 8 Attersee. 9 Litzlberg, 4 sites. 10 Seewalchen, 3 sites. 11 Kammer, 2 sites. 12 Weyregg, 2 sites. 13 Kammerl. Traunsee: 14 Gmunden. 15 Traunkirchen, plus 3 unsubstantiated sites. Drawings: Walter Strasil.

wickerwork and cord complexes) and from Schärfling (Gabelholz) have been discussed in detail by Holzer and O Cichocki (Antl-Weiser and Holzer 1995; Cichocki 2002).

As for the macrobotanicals, the pile-dwelling settlements contained a large quantity of seed, moss and leaf samples which provide an objective database for the reconstruction of the surrounding environment. Based on the macro-botanicals extracted from the sediment samples from the excavation conducted by Offenberger at See on Mondsee (1982–6), and from pollen analyses from this area (Schmidt 1986; Pawlik 1993), the area featured mixed woodlands dominated by fir and beech with some yew. The cultivated and gathered wild plant remains provide information about the proportion of subsistence the Neolithic inhabit-ants derived from plants. The quantitatively most significant cultivated plant was linseed or flax (a source of oil) and the most important grain was emmer. Smaller quantities of barley, einkorn and opium poppy (a source of oil and fibres) were also identified. Among the wild plants gathered, hazelnut, wild apple, wild strawberry, raspberry, blackberry and black elderberry are the most important.

Archaeological finds

Since the discovery of the Upper Austrian pile-dwelling stations in the mid-nineteenth century (the first were Seewalchen on Attersee in 1870, Gmunden on Traunsee in 1871 and the station See on Mondsee in 1872), the finds from the lakes have accumulated considerably. In the beginning, Viennese scientific institutions such as the Academy of Sciences, the Anthropological Society and even a private scholar, the manufacturer Matthäus Much, financed expeditions in order to bring a large number of finds to the surface via dredging shovels. The majority of the finds went into public collections. Particularly before the First World War, a resident of Seewalchen on Attersee, Theodor Wang, dredged up prehistoric finds along with the sand that he was quarrying from the Attersee. He sold most of them to Austrian museums (mainly to the Natural History Museum in Vienna) as well as to a private collector, Max Schmidt of Vienna–Budapest. The site locations were not always clearly defined, however, two mono-graphs occupy themselves in detail with the finds (Franz and Weninger 1927; Willvonseder 1963–8). Recently the ceramics and stone tool catalogue of the Much collection was submitted as a dissertation in Vienna (Bachner 2002).

At the beginning of the 1960s, activities were initiated at the sites by local Upper Austrian museums. Skin divers surveyed the site of See on Mondsee, recovering a large number of restorable ceramic vessels. They consisted mainly of undecorated wares: a particularly important contribution to prehistoric research (Kunze 1981). Their typology points to inter-regional contacts.

A systematic documentation of Austrian lacustrine settlements by divers was organized by the Federal Office of Monument Protection between 1970 and 1986. Finds were collected in sufficient quantities to permit dating of these sites. One exception to this was the station of Misling 2 on Attersee, where the extensive group of finds rich in data were recovered. After 16 years of successful surveying and localization, this work had to be suspended due to financial factors. The archaeological investigation of the station See on Mondsee by Offenberger (1982–6) was also affected. Nevertheless, this modern excavation yielded a considerable quantity of finds, including a large number of samples suitable for interdisciplinary investigations. These included: the systematic sampling of all the documented piles for wood classification; sediment samples for macro-botanical examination and animal bones for archaeozoological determination. These were examined by specialists at the Natural History Museum in Vienna over a period of six years, under the pile-dwelling research project, 'Bestandsaufnahme und interdisziplinäre Erforschung der Feuchtbodensiedlungen in Österreich', funded by the Austrian Science Fund (FWF) and the Fund of the Austrian National Bank. The results of archaeozoological studies (Pucher and Engl 1997) and an extensive catalogue of ceramics of the Mondsee stations (Lochner 1997) were published a few years ago.

Archaeological dating

The body of older research can only be sorted through typology or dated loosely by radiocarbon dating. There is, however, modern information: two sequential, well-documented layers from the station See on Mondsee from Offenberger's excavation (1982–6) (Offenberger 1986: 213–16). Unfortunately, the material from this excavation, including the finds recovered, has not yet been evaluated.

In 1981, the extensive ceramic inventory from the pile-dwelling settlements was classified by a random sampling of the ceramic types into three Neolithic (Mondsee 1–3) and two Bronze Age (Attersee 1–2) stages (Ruttkay 1981). This was accomplished through a comparison with inter-regional ceramic sequences and by considering of the three groups of metal finds established by Willvonseder (group 1: Copper Age; 2: Early to Middle Bronze Age; 3: Urnfield Culture) (Willvonseder 1963–8: 240–1). The Urnfield Culture was not considered in the new research.

The Mondsee group

Originally designated as the Mondsee group at the beginning of the twentieth century, it is now accepted as a group within the peripheral area of the Funnel Beaker Culture. This is based upon the rich variety of funnel-necked vessels used (Figure 4.2) and the battle-axes consisting of the flat-hammer axe, knob-butted axe and round-butted axe types (Ruttkay 1998: 344–9; Ruttkay 1999; Zápotocký 1992) (Figure 4.2). Some researchers use the incorrect designation 'Mondsee culture' instead of 'Mondsee group'. According to the ceramic classification of the archaeological groupings by Lüning (type – group – culture), despite being able to identify stages of finds, he states that Mondsee is not a culture. The small scale of the dispersal area leaves 'group' as the only appropriate designation (Lüning 1976: 149; Preuß 1996: Map 5). The presence of wares appearing to be characteristically Mondsee at a young Neolithic site does not confirm the site as

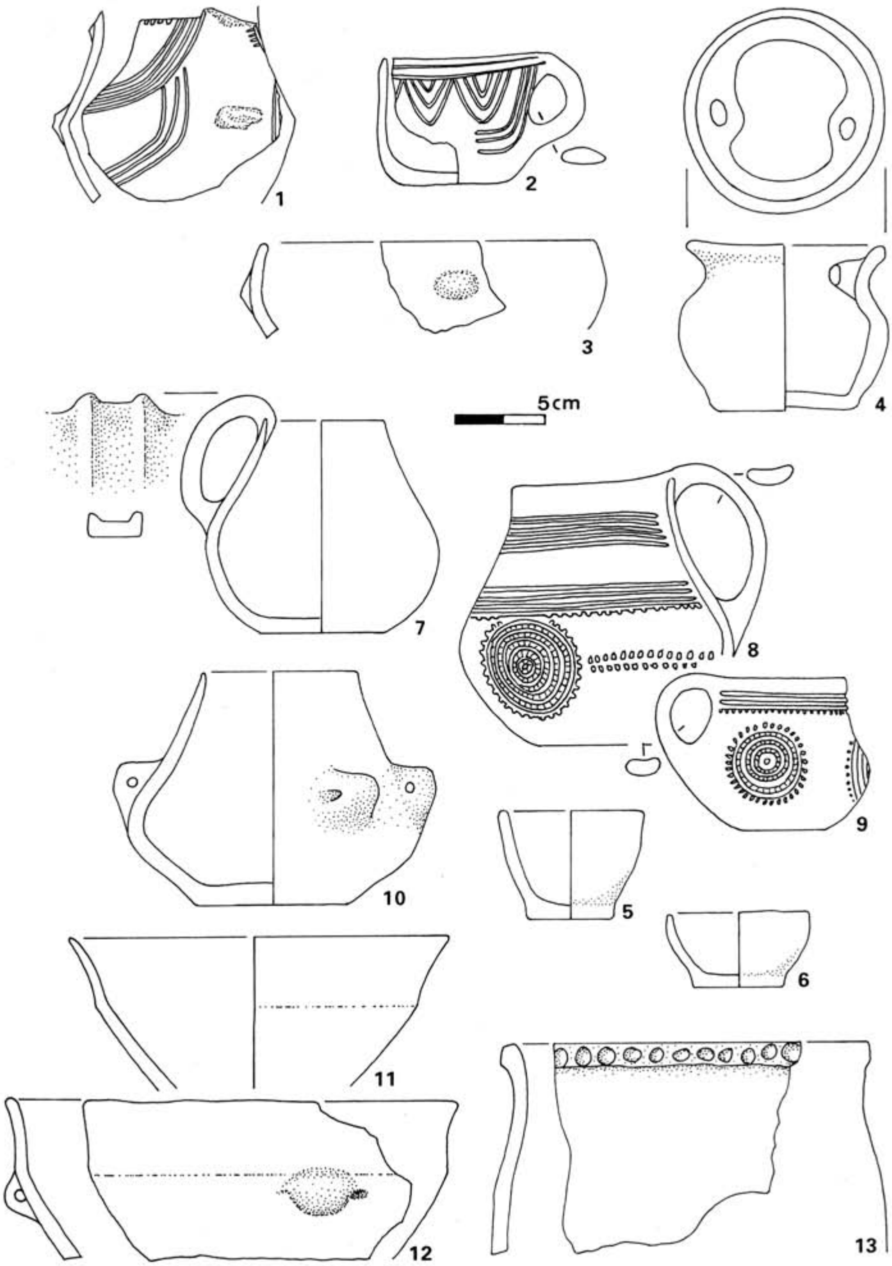

Figure 4.2 Site of See on Mondsee, Upper Austria. Ceramic selection from the Mondsee group. 1–6 Mondsee 1; 7–13 Mondsee 2. Drawings: Walter Strasil after Lochner 1997 and Bachner 2002.

belonging to the Mondsee group. B. Ottaway proved this clearly with neutron activation analysis of samples from the hilltop settlement on Götschenberg near Bischofshofen, in the province of Salzburg. The clays of the undecorated native wares (Alpine Altheim) were clearly different from those of the decorated Mondsee shards (Lippert 1992: 43). The Mondsee wares at Götschenberg were imported ceramics, despite the proximity to the Mondsee territory. This development strongly challenges some maps of the Mondsee group.

Socio-economic aspects of the Mondsee group

The eastern groups of the Circum-Alpine lacustrine settlement sphere were distinguished by a developed 'industrialization' in the form of early copper processing. Fragments of casting crucibles, drops from casting and pebble artefacts with traces of copper furnish clear evidence of such activities in the pile-dwelling settlements. In the Late Neolithic, we have a proof of this activity from Upper Austria to Upper Swabia, as well as in central and eastern Switzerland. According to Matuschik, these form the northern Alpine metallurgical sphere (Matuschik 1998). To date, no crucible fragments have been found west of Zugersee (Hafner and Suter 2000: 202–5). The metallurgical activities in the pile-dwelling settlements do not appear to be an improvised sideline for the native farmers. This applies in particular to the Mondsee group. Here, 160 casting crucibles, including many fragments, have been documented. A further 81 contemporaneous crucible fragments originate from eastern Switzerland and south-western Germany (Matuschik 1998). One hundred and twenty-one pebble artefacts with copper traces are known from Arbon-Bleiche 3 (Leuzinger 1997). Ernst Pernicka, in the context of the pile-dwelling project and through the analysis of 70 artefacts, recognized a specific kind of copper at Mondsee, calling it 'Mondsee copper' (presented in the next section of this article). It is arsenical, but otherwise quite pure (Obereder *et al*. 1993). The processing of copper by the Mondsee people seems to have been particularly profitable. Mondsee copper has been found on casting crucible fragments in the surroundings of Prague (Makotřasy) and in central Moravia (Náměšt' na Hané, District of Olomouc and Laškov, District of Prostějov), and in native metal types in the Funnel Beaker sphere (Pleslová-Štiková 1985; Šmíd 1998). Considerable quantities of arsenical copper from the Eastern Alpine region reached the northern group of the Funnelbeaker culture between 3800/3700 and 3300 cal. BC (Klassen 2000: 235–8). If one considers the entire complex of Neolithic finds from the pile-dwelling settlements in the Salzkammergut lakes, the general prosperity of the inhabitants was outstanding. This is demonstrated convincingly by the wealth of copper axes and copper daggers (in the pile-dwelling project, 37 whole or fragmented axes, as well as 11 daggers, were documented) (Obereder *et al*. 1993). In order to appreciate this properly, a comparison with the body of finds from the typologically related and contemporaneous Altheim Group should be made.

The Mondsee husbandry certainly did not exceed a very primitive level. The domestic animals were comparatively small. Similar data are presented by other areas with pile-dwelling settlements. The Mondsee people had to supplement their meat needs during the winter months by hunting. This is indicated not only by the relatively high proportion of game (30 per cent) in the bone waste of the See on Mondsee settlement, but also by the large proportion of arrowheads (40 per cent) among the 1,125 flint artefacts from this station (Antl-Weiser and Holzer 1995; Pucher and Engl 1997). The inhabitants of the pile-dwelling settlements are generally referred to as 'pile farmers'. At Mondsee, this is not entirely accurate. The most prominent elements of the archaeological record are the metal finds: in particular, the evidence of local copper-processing. These skills are characteristic of the Mondsee population. In the social structure, this indicates a place for a functional 'copper casting guild' (similar to Matuschik 1998: 244–5). It must be stressed, however, that copper-processing in the fourth millennium BC in Central Europe is not conceivable without a spread of metallurgy from the Balkans and the Carpathians (Strahm 1994: Figure 4 and 27; Matuschik 1997, 1998: 239–45).

The Mondsee group and the rise of metallurgy in Central Europe

Thanks to recent research, evidence of metallurgy and the earliest use of metals in Central Europe has emerged from considerably earlier periods. Accounts of the first metal objects dating to the late fifth millennium BC, in context of the horizon of the early Münchshöfen group, were published in the 1970s. These included an awl and a spiral ring from Schernau in Lower Franconia and a circular, slightly concave copper disc from Hornstaad-Hörnle on the shore of Lake Constance, dendro-dated 3917 BC. Of particular interest in the context of metal production is the Mariahilfbergl site in Brixlegg, Tyrol, Austria, where evidence for the smelting of copper ores has become known with a radiocarbon age of 3960–3650 cal. BC (Bartelheim *et al.* 2002). In south-eastern Europe, this is of course the period of a flourishing copper metallurgy with copper-mining attested at Rudna Glava in Serbia and Ai Bunar in Bulgaria. Copper-smelting, however, was never unequivocally documented in the field, although copper-production at Ai Bunar and Majdanpek, another large copper deposit in Serbia, was indirectly proven by relation to copper artefacts (Pernicka *et al.* 1997).

The metal inventory of the Mondsee-Altheim-Pfyn horizon (from 3800 BC) in the Alpine region is considerably larger than in the preceding period and typologically far more varied. Unfortunately, most of the metal comes from isolated finds, and only a few can be dated by associated pottery finds. There are, however, some secure contexts, such as the copper beads and a chisel from Burgäschisee-Süd in Switzerland as well as a piece of copper wire and a dagger from Reute, close to Lake Constance. Two regional concentrations of metal finds are observed, namely north-east of the Alps in the Salzkammergut, with Mondsee as the eponymous site, and in eastern Switzerland, especially around Lake Constance and Lake Zurich. Find lists including crucibles and casting spills have been published and continuously updated (Bartelheim *et al.* 2002). These regions roughly coincide with the settlement areas of the Mondsee group and the

Pfyn culture. The Altheim group lying in between these two has occasionally been described as having rejected metal but this may be due either to a social filter like different deposition habits or simply due to the present state of research.

The metal composition in this horizon is rather uniform, especially in the Mondsee group. Most artefacts consist of arsenical copper without other minor elements (Ottaway 1982; Obereder *et al*. 1993; Matuschik 1998). This type of copper is also very common in the Carpathian basin during this period, as well as around the Black Sea. This relation seems to be corroborated by the pottery of the Mondsee group, which shows similarities to the late Funnel Beaker cultural period, and the Bajč-Retz-Gajary horizon of the very latest Danubian traditions. Little can be stated with certainty concerning the provenance of this copper type. The impressive number of finds and the fact that numerous crucibles attest to local production of copper implements have led many researchers to conclude that the metal was produced locally.

At the nearby Mitterberg mines, however, copper production seems to have begun in the Early Bronze Age. The bulk of metal production may not be earlier than 1800 BC, i.e. the late phase of the Early Bronze Age, peaking in the Middle Bronze Age and the early phase of the Late Bronze Age (Eibner 1982). Furthermore, the Mitterberg mines are located in the greywacke zone, a geological unit of the northern Alps that stretches from eastern Switzerland almost to Vienna. It contains many copper deposits and small occurrences that are mostly characterized by the presence of nickel and fahlore minerals mixed with chalcopyrite, the main copper ore. Thus, the copper products tend to contain antimony and nickel besides arsenic, like the rib ingots of the Early Bronze Age that may well derive from this region. The only other major copper deposits in the eastern Alps are the fahlore deposits of the Inn Valley (where Brixlegg is also located) in a dolomite setting. These ores are bound to produce copper with high arsenic, antimony and silver concentrations. The Final product is the so-called 'Ösenring' copper that must have been produced at Mariahilfbergl as well. As there is no major Alpine copper deposit known that is associated with arsenic alone, the origin of the ore used to produce Mondsee copper is uncertain.

There is no clear evidence as yet of the smelting of copper ores in this period. It has been claimed that below the Mitterberg mining region, smelting had occurred at Götschenberg near Bischofshofen (Moesta 1992), but the finds can also be interpreted as casting remains (Bartelheim *et al*. 2002). Incidentally, the adhering copper in the crucible from that site also resembles Mondsee copper and, therefore, is unlikely to derive from Mitterberg.

Absolute chronology of Mondsee

From the Neolithic pile-dwelling stations on Mondsee and Attersee, 24 pile samples have been ^{14}C dated. They resulted in group calibration values of 3700–3100 cal. BC with a 68.2 per cent probability (Ruttkay 1998: Table 30). This time period covers both the young Neolithic Mondsee group (Mondsee 1 and 2) and the beginnings of a Final Neolithic settlement of some of the stations (Mondsee

3). One can add Mondsee 3 to the Bavarian Chamer culture, also present in the Salzkammergut lake region. Its presence in the pile-dwelling stations was confirmed by a random sampling of a selection of Final Neolithic ceramics (Ruttkay 1998, 2001: 78 and Figure 11). Mondsee shards in foreign regions resulted in typological linkages with the horizon of the Gemischte Gruppe (Mixed Group)/Baalberge (also called the Bajč-Retz-Gajary horizon) in Lower Austria (Ossarn-Rosenbühel) and with the horizon of the late Moravian Funnel Beaker Culture/late Boleráz in central Moravia (Laškov-Na kruse: also Mondsee copper found here). The first horizon marks the beginning of Mondsee 1 in the thirty-eighth century BC; the latter horizon marks the flourishing of Mondsee 2 in the middle of the fourth millennium BC (Ruttkay 1981: Figure 7 and 8; Šmíd 1996: Figure 18/1, 1998: 135–6; Matuschik 2001: Figure 3)

The pile-dwelling settlement on Keutschacher See, Carinthia

This pile-dwelling settlement in Keutschacher See, in the administrative district of Klagenfurt-Land, Carinthia, is one of the most important pile-dwellings in Austria. It was discovered by the 'Commission for the Search for pile-dwellings in Austrian lakes' initiated by the Austrian Academy of Science in 1864. This project followed the Swiss initiative to find more lake settlements after the first discovery (Ober-Meilen) on Lake Zurich.

Site location

The Neolithic settlement is situated on top of an underwater hill covered with a thick layer of lacustrine chalk sediments. On its plateau, more than 1,600 posts are still *in situ*. The shallow part of this site was investigated in the 1950s within an interdisciplinary project initiated by the Federal Office of Monument Protection (Mossler 1954). New investigations 1993/4 and from 1999 on produced a new pile plan which was calculated with the help of specially designed software and combined with a sonar underwater relief to give a 3D impression of the underwater position of the piles (Cichocki 2000) (Figure 4.3).

The piles do not show any arrangements that would allow us to ascribe them to particular buildings. They reach some 30 cm into the lake floor. This fact, together with the absence of cultural layers in most areas of the settlement, is evidence of severe erosion. The piles are round trunks, 15–25 cm in diameter, some of them standing in groups of two or three. The spectrum of wood species of some 200 piles contains *Quercus* sp., *Fagus sylvatica*, *Alnus* sp., *Populus* sp., *Fraxinus excelsior*, *Tilia* sp., and *Abies alba*. The occurrence of oak, which is unique in Austrian pile-dwellings, was the basic source for dendrochronology. Five large oak trees from the Neolithic were lying in the area of the piles and provided a mean chronology with 294 rings. Due to the lack of local standards, the floating chronology was synchronized by Billamboz at Hemmenhofen, using several Neolithic standards. The results of the ^{14}C and the dendro-synchronization matched perfectly with an end date of 3887 BC. With the help of this standard,

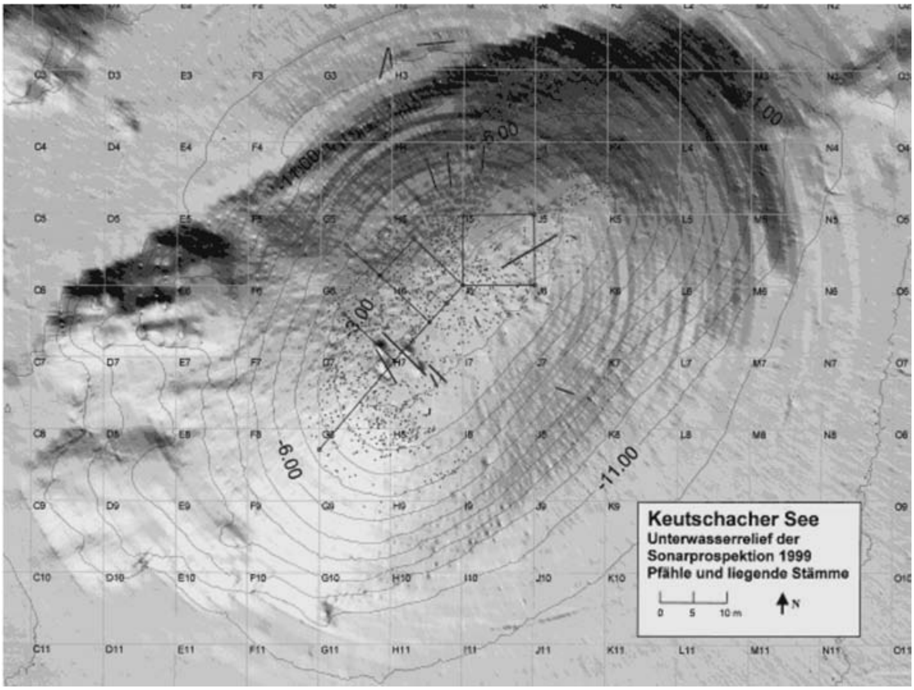

Figure 4.3 Keutschacher Lake, Carinthia. Underwater sonar relief and position of 1,684 piles as measured up to 1999. Image: Otto Cichocki.

two piles with a preserved last ring and bark were dated to winter 3947/6 and winter 3864/3 BC (Cichocki 2000, 2003).

A wooden construction made of a plank with two rows of inserted twigs is dated to 900 BC and was perhaps a fish-trap. Some other piles are dated to the Middle Ages (AD 1300–1490). Some cores were drilled into the sediment to search for the 'cultural layer'. This layer was found in several places and identified as a single layer with a thickness of 15–20 cm. It contained shells of hazelnut (*Corylus avellana*) and organic fibres. Pollen grains within this very fine lake chalk are well preserved and will help to reconstruct climatic changes, as well as the first human impact on the surrounding landscape. At a depth of two metres, organic layers were found which date to 14,000 BC.

Ceramics

Samonig (2003, 2004) typologically classified the Late Neolithic ceramics from Keutschacher See (all of them were surface finds without stratigraphic connections) into four sequential stages of the Kanzianiberg-Lasinja group (Stage 1, Stage 2 in three phases: a, b, c). At the same time, the last phase (Phase 2c) was set up as Facies Keutschacher See (Figure 4.4). The older stages (1, 2a) form a unit based on clay investigations and on the ceramic typology. These wares carry salient younger Epilengyel period characteristics. Epilengyel is to be understood here as defined by Pavúk (Pavúk 2000). The further indigenous development leads, judging by the ceramics, to Facies Keutschacher See. Its characteristic, richly decorated, encrusted ceramic appears in the southern Transdanubian area (a furrow-stitch decorated jug covered with encrustation, a single find from Keszű, Baranya County) and among the finds from the old excavation of a hilltop settlement in the Upper Austrian Enns Valley at the Rebensteiner Wand near Laussa (Kalicz 1974: 90/47, Tables 10/2a, 2b; Mitterkalkgruber 1992: 62, Tables 18/4, 56/3). The characteristic spiral motif of the vessels mentioned here can also be found, although thoroughly isolated and modified, on the Mondsee wares (Franz and Weninger 1927: Table 18/5). The settlement in Keutschacher See with Lasinja ceramics is, however, fundamentally oriented toward the east and southeast and is older than the Mondsee group. The last young Neolithic settlement phase (Facies Keutschacher See) still reached into the period of the encrusted ceramics (furrow-stitch decorated ceramics) in the Scheibenhenkel (Disk Handle) horizon: Gemischte Gruppe/Baalberge in Lower Austria and Moravia (Šmíd 2001: 604; Matuschik 2001: Figure 9). The Facies of Keutschacher See found in Upper Austria should be regarded as foreign wares, a south-eastern component that provided the stimulus for the Mondsee group. According to Cichocki, ^{14}C measurements of the sampled piles from the island settlement in Keutschacher See resulted in calibrated dates of 4100–3700 BC (Samonig 2004: 32). Important is also the fact that fragments of casting crucibles with traces of arsenical copper were found in this pile-dwelling site. According to dendro-dating, two piles are to be dated to 3947 and 3871 BC; thus, these crucible fragments supply the oldest evidence of the metallurgy sphere using arsenic copper in Central Europe (Samonig 2004: 32–4, 77–8; Cichocki 2003: 18–19; Matuschik 1998: 211–12).

The domestic fauna of Austrian lake-dwellings and its affinities

Very few archaeozoological studies of lake-dwelling sites in Austria have been carried out up to now. Only the sites Schärfling and See on Mondsee and the site in Keutschacher See in Carinthia have been treated in detail. The new faunal assemblage from the late Neolithic site Mondsee-See, recovered from 1982–5, was studied by Pucher and Engl (1997), continuing the preceding work of Wolff (1977). More than 5,000 animal bones were identified in this new material. About one-third were bones of wild animals, consisting of a comparatively high proportion of chamois bones, forming a quite noteworthy feature of this Alpine bone assemblage. Moreover, it became necessary to establish sufficient criteria for the identification of chamois bones, since this had not been done before.

The animal husbandry of the site resembles, in most respects, the recently well-examined and roughly contemporaneous Swiss lacustrine sites. Cows were slaughtered predominantly in early maturity and most bull-calves shortly after

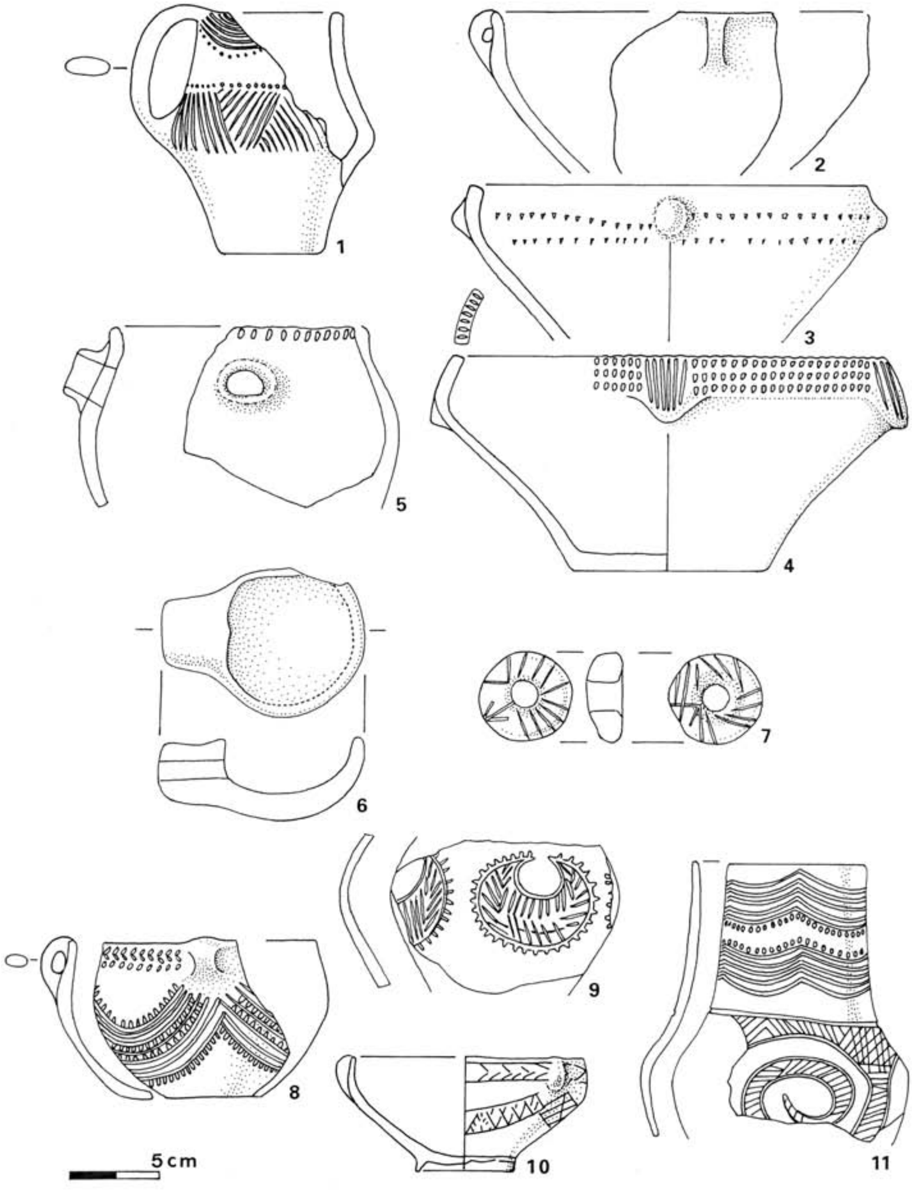

Figure 4.4 Pile-dwelling settlement on Keutschacher Lake, Carinthia. Ceramic selection of the Kanzianiberg-Lasinja group. 1–6 (Stage 1 and Phase 2a); all others Phase 2c=Facies Keutschacher Lake. Drawings: Walter Strasil after Samonig 2004.

birth. Few cattle survived to old age. Cows probably produced little milk, as meat production was their main purpose. On the other hand, the age distribution of sheep and goats, as well as the preference of females, points to a secondary exploitation, likely more focused on milk than on wool. The sheep were probably still a hairy breed. Pigs were usually slaughtered young. A number of observations have indicated that animal husbandry could not supply the entire meat demand. Subsidiary hunting of red deer and chamois was therefore necessary, particularly during the late autumn and winter, to fill the deficient periods between appropriate slaughtering seasons. Dogs were also consumed occasionally.

The cattle among the Mondsee fauna were conspicuously small in size compared with the contemporaneous fauna of the adjacent Danubian area, or northern parts of Central Europe. They also had slightly shorter and more sharply curved horn cores. Not only were cattle taller in the Danubian area since the emergence of the Linear Pottery Culture, but pigs with considerably increased withers height appeared too, at the latest during the Late Neolithic. As a result, the marked faunal differences seem to isolate the Mondsee fauna in its eastern Alpine boundary. A similar domestic fauna, however, is also known from Swiss Cortaillod and Italian Lagozza sites.

The possible reasons for these size differences have been discussed on various occasions. Although some authors have emphasized local ecological causes, no constant pattern could be observed, except for a general geographic and chronological distribution. Moreover, during the Early Bronze Age, when the cattle in the same eastern Alpine area were at least as tall as the contemporaneous Danubian cattle, the modifying effect of local ecological factors as claimed appears to be negligible. The widespread practice of always attributing size differences to some ecological circumstance does not take into consideration (outside of the confines of the laboratory) that the magnitude of size reduction caused by the stress of chronic malnutrition is strictly limited by the resulting collapse in reproduction. Therefore, more attention has recently been paid to the subsequent diversification of husbandry communities during their Early Neolithic spread over Europe (Higham 1968: 17; Clason 1973; Bökönyi 1974; Chaix 1976; Stampfli 1992; Benecke 1994: 101). From this point of view, it seems more appropriate to attribute the size differences between Danubian and Alpine cattle to the existence of at least two different breeds, rather than to local conditions (Benecke 1994; Pucher 2001). Despite the typological affiliation of Mondsee pottery to the adjacent Funnel Beaker horizon, it seems more appropriate to trace back the Mondsee domestic stock to the (south)-western breeding community appearing in most sites of the Chassey-Cortaillod-Lagozza group and some south-Alpine/north-Italian/Slovenian groups, rather than to northern or eastern influences. A similar situation is probably the case in some other groups of the Swiss and German Alpine foreland, such as in the Pfyn culture. There is no need to postulate the complete isomorphism of economic systems and archaeological entities (Glass 1991: 23).

To examine the introduction/trade route for domestic stock from the south or west, it was useful to study the bone assemblage from the slightly earlier lake-dwelling settlement of Keutschacher See in Carinthia, which is associated with pottery of the south Alpine Lasinja type. This material, recovered in small quantities between 1983 and 1994, yielded about one thousand diagnostic bones. Almost three-quarters of the bones belonged to game, predominantly deer, but fourteen other wild species were represented, including chamois bones. The remaining bone samples from domestic animals were limited and their economic interpretation was therefore difficult. The moderate size of cattle and pigs, however, was clearly visible and differed little from the Mondsee fauna. Perhaps consideration should be given to the possibility that the range of variation in pigs was extended by a few individuals that resulted from occasional crossbreeding with wild boars. Again, there were more parallels to the south or west than to the east or north, except for the Mondsee assemblage.

Animal husbandry at Mondsee and Keutschacher See was the earliest documented farming activity in that eastern Alpine area, but by which route did the domestic animals come to the lakes? Did the Neolithic farmers bring their domestic stock into the Alpine valleys, penetrating progressively from the neighbouring lowlands, as their different pottery suggests?

Alternatively, did they migrate through the main Alpine valleys over a long distance, as their domestic fauna suggests? Perhaps some indigenous groups adopted some traits from the surrounding Neolithic cultures. The latter would explain the contradiction between some of the common features of the lacustrine settlements, such as their common fauna among other correspondences, and the remarkable differences in parts of their pottery, which reflects diverse influences from outside their Alpine habitat. Perhaps the smaller domestic cattle of the slightly earlier western communities were more suitable for the narrow lacustrine habitats, than the heavy and clumsy cattle of the Danubian breeders, and therefore were preferable.

Why is it just the domestic fauna that is relatively uniform? This is far less a question of cultural history than a question of biology. Successful farming requires animal breeds which do not suffer under local conditions but indeed adapt well to them. This adaptation could not be achieved by the farmers in a short period. It was the result of a selection process that in those times was governed more by nature than by intentional breeding. Along with the type of fauna, the experience in keeping them had to evolve. This particular biological knowledge usually develops, under pre-industrial conditions, as traditions passed on from generation to generation. This view explains why the fauna was far less a focus of trade and exchange than were other objects such as pottery and other short-lived fashion accessories. Once adopted, the fauna usually remained in the area for centuries, evolving only gradually.

Conclusions

The pile-dwelling research in Austria has seen a pleasing progress since the large-scale summary on the state of research written by Willvonseder in the mid-1960s. Two new aspects define this period: the application of modern technology in the field investigation (underwater archaeology) and the increased support from the natural sciences, such as nuclear physics (radiocarbon dating, neutron activation analysis) and dendrochronology. It is to be emphasized that we are now more familiar with the location of half of the well-known Neolithic settlements on the Mondsee and Attersee (through underwater surveying). Similarly, the role of early metallurgy in the life of the pile-dwelling people in the fourth millennium BC is far more comprehensible. Twenty-four ^{14}C (pile samples) dates now accompany the typological classification of the Neolithic finds from Mondsee and Attersee. The significantly increased body of finds, as well as old finds, were made accessible in part in scholarly editions of the research. The Prehistoric Commission of the Austrian Academy of Sciences made this possible, by publishing a series on the pile-dwellings: *Studien zur Pfahlbauforschung in Österreich* (Studies on pile-dwelling research in Austria). Three volumes of this series have already appeared and some others are in preparation. An interdisciplinary research project was supported by two research funds for a period of six years and the first dendro-dating chronology for the Neolithic in Austria (Keutschacher See) has indeed emerged from this site.

One of the most important results of the last few decades concerns the social structure of the population of the pile-dwellings at the edge of the eastern Alps. It shows a functional 'Copper-casting guild' from the first third of the fourth millennium BC onwards. The level of provision for their subsistence (evidence of cultivated plants and domestic animals) had apparently been sufficient. According to absolute chronological data, the beginning of early arsenical copper usage can be located in the south eastern Alps (Keutschacher See). Its peak, however, occurred somewhat later, in the north-eastern margin of the Alps in the Salzkammergut (Mondsee and Attersee).

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5

PAST AND PRESENT LAKE-DWELLING STUDIES IN SLOVENIA

Ljubljansko barje (the Ljubljana Marsh)

Anton Velušček

Introduction

All the major lacustrine and marshland prehistoric settlements in Slovenia are to be found within the Ljubljana Marsh complex. Since the first discovery of ancient settlements in the second half of the eighteenth century, the Marsh has been researched extensively yielding extremely well-preserved archaeological evidence. This chapter will not only stress the importance of wetland archaeological research in Slovenia, but it will also show how the Ljubljana Marsh settlements are vital to understand the lake-dwelling phenomenon as a whole in the Alpine region and surroundings.

Geographic description and formation

The Ljubljansko barje is situated at the edge of the south-eastern Alps in central Slovenia and it covers an area of 163 square kilometres. Numerous isolated hills rise above the marshy central area (287–90 m above sea level): Sinja Gorica (293 m a.s.l.), Blatna Brezovica (326 m a.s.l.), Bevke (345 m a.s.l.), Kostanjevica (367 m a.s.l.), Plešivica (390 m a.s.l.), Grič (342 m a.s.l.), Vnanje Gorice (373 m a.s.l.), Grmez (320 m a.s.l.), Babna Gorica (328 m a.s.l.) and other summits along the edge (Lah and Adamič 1992).

The marsh was formed by the submersion of a wide area of the Ljubljanska kotlina (Ljubljana basin), and later also the Ljubljansko polje (Ljubljana Plain) and Ljubljansko barje (Figure 5.1). The Ljubljanska kotlina in its broader sense encompasses the entire submerged area from Ljubljana to Jesenice, and in its narrower sense the Ljubljansko polje and the Ljubljansko barje. The wider basin is an older formation. Its development started about 30 million years ago, while the Ljubljansko polje and the Ljubljansko barje are younger formations, dating back about two million years. The Marsh is covered with numerous faults, along which individual rock blocks are sunk. Boreholes and geophysical measurements revealed that beneath the younger deposits, the bottom is composed of submerged

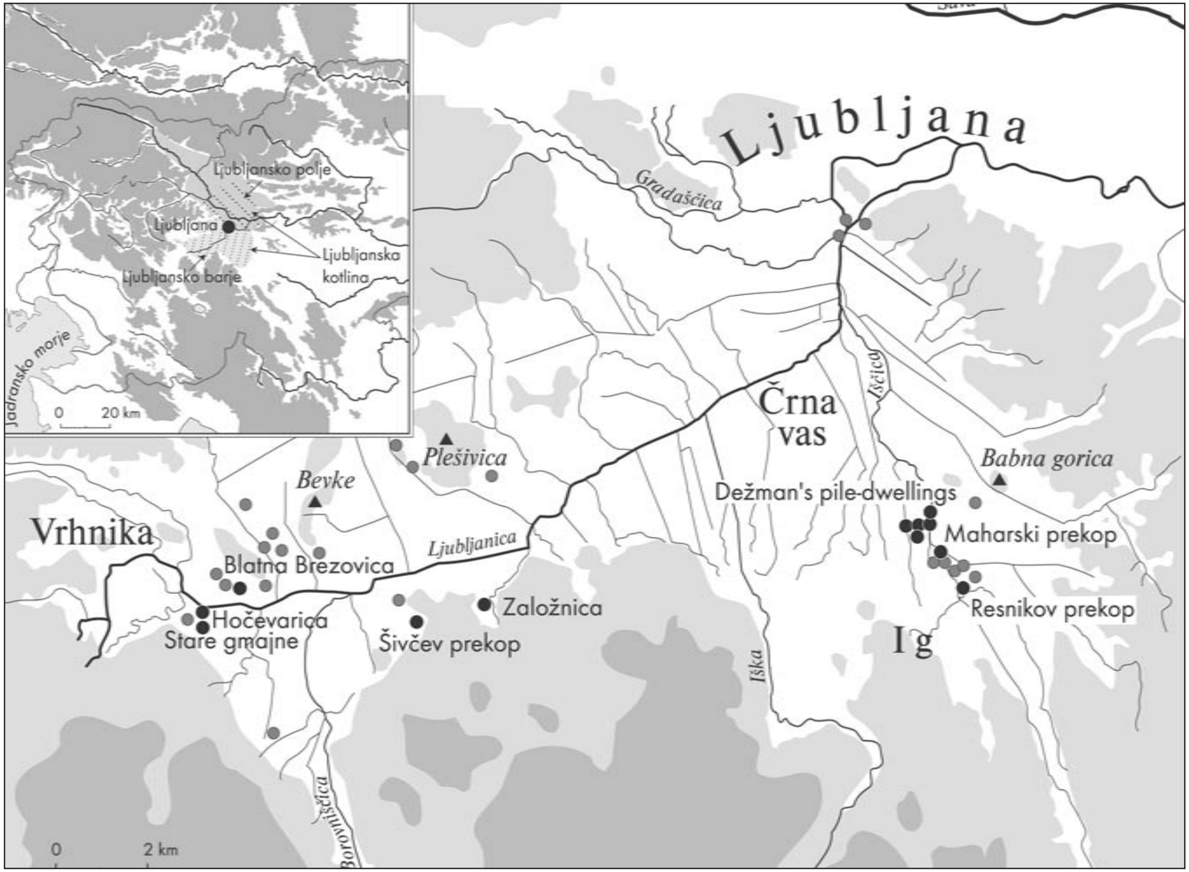

Figure 5.1 Ljubljansko barje (Ljubljana Marsh), Slovenia. Computer design by Mateja Belak, Inštitut za arheologijo ZRC SAZU.

parts of various depths. The Marsh is deepest in its south-eastern part; this was determined by a borehole made near Črna vas (Figure 5.1), which reached a depth of 117 metres. The bottom slowly rises from these depths up towards the edges or the isolated hills, which are in fact parts of the Ljubljansko barje that had not sunk below the young alluvium and have remained dry land. Their geological composition is consistent with that of the edges and the base. Water, sediments and other various deposits subsequently filled all the depressions that were formed by submersion. The rate of submersion proceeded relatively fast; the bottom submerged one metre in 500 years.

A rich network of waters flows through the Ljubljansko barje. Some of the waters originate far from within the hinterlands and enter the Marsh as surface waters (Iška, Gradaščica, Borovniščica, Želimeljščica and other minor tributaries). Other rivers originate in the karst region (Ljubljanica, Bistra, Iščica). Karst Rivers have a very mild inclination. At the end of the nineteenth century, Podhagsky determined that the difference in altitude between Vrhnika and Ljubljana was barely one metre. There is no gravel in such riverbeds, because the river has nowhere to get it from and its flow is too slow to move the sediments. The Ljubljanica River carries its cargo in the form of dissolved limestone. The situation in the surface waters, which are usually of a more torrential character, is very different. When the water is high they carry large quantities of gravel and sand, and can quickly fill large areas. The surface waters have been filling the Ljubljansko barje for thousands of years in this manner, at times forming lakes with their clay deposit. This new load caused the bottom of the Marsh to submerge even quicker. Gravel sediments are prevalent in the Ljubljansko polje, while the Marsh presents a mixture of gravel, clay and peat layers.

The border between the Ljubljansko polje and the Ljubljansko barje may be drawn through the centre of Ljubljana in the direction from the Castle towards the north-east, although sometimes gravel from the Sava River finds its way deep into the Marsh area, along the western edge of the city. The dominance of the Plain is most distinctive in the older periods of the geological history of the Marsh. The influence of the Marsh can be felt in the Plain area during the younger geological periods. Gravel from the Sava River filled the mouth of the Ljubljanica River and caused this situation, as did the varied rates of submersion of the Plain and the Marsh.

The sequence of the sediments in the Ljubljansko barje, which boreholes helped to determine, aided the reconstruction of the dynamically changing circumstances: at one time the Marsh was a large gravel plain with individual small ponds, and at another it was a more or less shallow lake with rich flora and fauna, then an impassable swamp and later a peat bog. The upper layers in the boreholes at Črna vas are the most important for observing the Holocene period. They reveal that close beneath the surface there lies a 15-metre deep layer of loamy soil, sometimes interlaced with layers of sand. It harbours a rich fauna of snails and bivalve shells. This abundance of snails and shells gave the clay its Slovenian name – 'Polžarica' (snails). The snails appear in large quantities, while the other shells are relatively few. The remains of the molluscs in this clay are not evenly distributed throughout the Marsh. At some locations they are abundant and at others much less so. The snails in the clay are not indicative of any shorter geological period and the age had to be determined by other methods, but they do reflect the situation of the former lake. Above the 'Polžarica' loam layer lie other layers rich in vegetal remains: these is brown clay, peat soil, peat and humus. Peat is formed in marshy areas under specific conditions. The conditions are ideal when the land sinks evenly, so that the swamp neither dries nor forms a lake. The stratigraphy of the pile dwellings and other archaeological sites (e.g. the Roman road along the northern edge of the Ljubljansko barje) revealed that the peat was formed after the period of pile dwellings and perhaps even during the Roman period (Pavšič 1989).

The history of research on the pile dwelling settlements in the Ljubljansko barje

The period of the oldest discoveries of the pile dwelling remains in the Ljubljansko barje coincides with the beginning of the first projects of drainage and reclamation of the Marsh during the late eighteenth and early nineteenth centuries. Consequently, between the years 1826 and 1828, during excavation of one of the irrigation ditches in the area of present day Ljubljana, a small, perhaps prehistoric, wooden dugout was found at a depth of 1.5 metres. It broke along the annual rings when it was exposed to the open air. It was a chance find, which researchers had not yet known how to evaluate at the time. However, news of pile dwellings found in the Swiss lakes during the 1850s galvanized the research community to the extent that they began recording the prehistoric finds from various parts of the Marsh. Two wooden dugouts were found while cutting peat in the northern part of the Marsh between 1856 and 1858 (Hitzinger 1857; Deschmann 1858). Three axes of stag-horn were also discovered in the same period (Hitzinger 1857; Deschmann 1858, 1888). A hammer form axe made of serpentine was found during the construction of the railway overpass in the extreme south-west (Deschmann 1888). On the basis of these finds academics conjectured that, similarly to Switzerland, there would have been pile dwelling settlements in the Ljubljansko barje (Hitzinger 1865; Hochstetter 1865).

And they were right. On 17 July 1875, Martin Peruzzi, committee member of the District Roads Committee in Črna vas, reported to the Regional Museum for Carniola in Ljubljana that whilst cleaning the ditches along the Ig road near the village Studenec (Brunndorf in German,today called Ig) the same summer, workers discovered piles driven vertically into the lake bottom, pottery fragments, stone, horn and bone tools, animal bones and charcoal. Dragotin Dežman (Figure 5.2), who recognized the importance of this discovery, immediately raised the necessary funds and organized the first official archaeological excavations in Slovenia. This occurred on 26 July 1875. During the excavations he followed the trail of the finds and within the next two years explored an area of over 10,000 square metres (Velušček 1997). The exact positions of these trenches are unfortunately unknown today, although the excavation chart from

Figure 5.2 Dragotin Dežman (Karl Deschmann), born Idrija, 3 January 1821, died Ljubljana, 11 March 1889. Photograph: Archives of the National Museum, Ljubljana (Narodni muzej Slovenije, Ljubljana).

1875 is preserved, and we also know the outlines of the major sites from 1876 and 1877.

The pile dwellings discovered by Dežman are often referred to as 'Dežman's pile dwellings' and are treated as a single unit. We now know for certain that these composed several chronologically varying settlements. The majority date to approximately the third millennium BC.

The impressive finds from the Ig area triggered a wave of exploration of prehistoric finds elsewhere in the Ljubljansko barje. Characteristically, it was mostly seekers of antiques that engaged in these explorations. In 1907 and 1908, Walter Šmid, the first specialized archaeologist working in Slovenia excavated the newly discovered pile dwelling near Notranje Gorice (Schmid 1910).

Then an interruption in research efforts followed: the First World War, the disintegration of the Austro-Hungarian Monarchy, the founding of the South-Slavic state. It was thus not until 1931 that Rajko Ložar again drew attention to the globally renowned pile dwelling culture of the Ljubljansko barje by publishing the *Vodnik po zbirkah Narodnega muzeja v Ljubljani (Guide through the Ljubljana National Museum Collections)*. Ložar was also the initiator of new field research in the Marsh, which he had to interrupt because of the oncoming WWII. Despite all this, he managed to publish several scientific articles on the topic of pile-dwellers (Ložar 1941a, 1941b, 1942, 1943). He was also the first in Slovenia to attempt to chronologically classify the Ljubljansko barje pile dwelling finds according to scientific methodology. In 1945, this recognized explorer unfortunately had to leave Slovenia for political reasons.

Anton Melik's work, *Ljubljansko mostiščarsko jezero in dediščina po njem (The Ljubljana Pile-Dweller's Lake and its Heritage)* was published soon after the Second World War. Melik (1946) treated the Ljubljansko barje mainly from the view of a geographer and historian. However, the author also devoted his attention to pile-dweller archaeology and culture; in the chapter on pile-dwellers he presented a broad literary opus connected to the topic of pile-dwellers in the Ljubljansko barje. His list of wooden dugouts is still the most comprehensive existing listing. Among post-war archaeological literature, Melik's work proved to be the most frequently cited piece of literature – for its discussion of the connection between the former lake and pile-dwellers.

In 1953, Josip Korošec, a specialist in Slovenian post-war prehistoric archaeology, began research work in the Ljubljansko barje. Together with his professional colleague Staško Jesse and the students of the Archaeological Seminar, he excavated the pile dwelling at Blatna Brezovica (Korošec 1963). Through contracts established with the locals, they discovered several other pile dwelling settlements in the vicinity of Blatna Brezovica in the same year. Also in the same year, pile dwellings were discovered at Resnikov prekop, Maharski prekop and Šivčev prekop, which is considered the youngest pile dwelling in the Ljubljansko barje, and at Založnica near Kamnik pod Krimom.

During their research efforts at Blatna Brezovica and Založnica the archaeologists managed to intrigue researchers from other professions. These comprised the significant beginnings of interdisciplinary research on the Ljubljansko barje. Alojz Šercelj made a palynological profile of the Založnica pile dwelling (Šercelj 1955b). The first xylotomical analysis was also carried out (Šercelj 1955a). Ivan Rakovec studied the osseous remains from some of the other pile dwellings (Rakovec 1955).

Workers chanced upon piles, charcoal, bones and pottery during the excavation of the Resnikov prekop; following the sample trenching in 1957 and the broader set research excavations in 1962, these pottery sherds proved to be the oldest in central Slovenia (Jesse 1954; Korošec 1964; Harej 1975).

The most comprehensive archaeological excavations in the Ljubljansko barje since the Second World War started in 1970. Tatjana Bregant opened a site on a fallow near Spodnje Mostišče, close to Jesse's trench from 1953. This pile dwelling, referred to as Maharski prekop in the literature, was again explored in 1972, 1973, 1974, 1976 and 1977 (Bregant 1996). Due to the interdisciplinary research approach, these investigations are still considered the most modern large-scale excavations carried out in the Ljubljansko barje.

In 1974, Zorko Harej, one of the key persons from the later period of research in the Ljubljansko barje, dug his shovels in the pile dwelling in Notranje Gorice and found the locations where Šmid had already excavated in the beginning of the twentieth century (Harej 1976). Several trenches were dug in the Notranje Gorice pile dwelling in 1979 during the excavation of sewer canals that crossed the layer of the pile dwelling culture (Harej 1980). The discovery of the Parte pile dwelling in the area of Dežman's pile dwellings is also attributed to Harej. An area of 640 square metres was researched during the years between 1976 and 1981. The platform of a pile dwelling was found during one of the excavation seasons. This is the only pile dwelling platform documented in the Ljubljansko barje (Harej 1978).

The next significant period concerning the exploration of the Ljubljansko barje is connected to the activities of Davorin Vuga. Among his most important achievements is the discovery of sites bearing evidence of the so-called stone industry without pottery. Vuga discovered the first such site already in 1974 at the edge of an elevation on the fallow at Gmajne just north of Ig (Turk and Vuga 1982). They presumably represent a Late Mesolithic settlement area. Minor trenches were excavated at some of the sites (Frelih 1986).

During the latest period, since 1995, intense interdisciplinary research has been conducted in the Ljubljansko barje, supervised by the Institute of Archaeology in the Scientific Research Centre at the Slovene Academy of Sciences and Arts, and in close cooperation with the Dendrochronological Laboratory of the Department of Wood Science and Technology at the Biotechnical Faculty of the Ljubljana University (Velušček and Čufar 2002). First, a precise topography of the area was made, thus revealing several new sites of pile dwelling settlements. The introduction of dendrochronology into the research efforts generated fresh data on the chronology of the area and data regarding the appearance of the settlements.

The Ljubljansko barje in prehistoric times

The earliest settlement of the Ljubljansko barje dates back to the Mesolithic. The sites from this period can be found on solid ground along the edges of the Marsh, most often at the feet of what are now isolated hills, although at the time they were islands in the lake. The population subsisted by means of gathering, fishing and hunting. The remains of bones indicate that the hunters were accompanied by dogs – the first domesticated animal (Pohar 1984). They did not produce any pottery at the time. The Mesolithic way of life endured in the Ljubljansko barje area until the sixth millennium BC. Neolithic herdsmen were already settling the eastern Adriatic coast during this period, and early farmers lived in the plains of today's Hungary and Croatia.

This picture changed drastically in the first half of the fifth millennium BC. Groups of people appear in the area of present-day central Slovenia, which includes the Ljubljansko barje, and they breed domestic animals, such as cattle and sheep, as well as engaging in agriculture. A characteristic novelty is that they manufactured solid, light-coloured pottery. Analogy permits the presumption that they maintained close ties with the mainly Neolithic cultures of the western Carpathian Mountains and the eastern Alps. They built their settlements, such as hillforts or terraces near river bends, on naturally protected spots.

The most important site in the Ljubljansko barje from this period is Resnikov prekop. This is a minor pile dwelling settlement of a dispersed type, which was probably located at the edge of the lake. Charred wheat grains indicate that the former inhabitants engaged in farming. They also tended to have some cattle, sheep and domestic pigs. The remains of fish and other bones suggest they were also fishing and hunting. Amongst the variety of game they also hunted elk, a relic from the last ice age, that still lived in the Ljubljansko barje.

The climatic conditions were probably as good as today, maybe even better. Wild grape pits that were found in the cultural layer of Resnikov prekop are indicative of this.

The next traces of human settlement in the Ljubljansko barje date to the second and third quarter of the fourth millennium BC. This is the period when copper mines were intensely mined in the eastern Alps and copper tools were produced. A shapeless fragment of pure copper and a fragment of a crucible with traces of copper inside it were discovered in a sample trench in the area of the pile dwelling at Hočevarica near Verd. Scuba divers found two copper axes in the nearby Ljubljanica River which typologically belong to the Hočevarica period, the second quarter of the fourth millennium BC. Somewhat younger fragments of crucibles, dating to the second half of the fourth millennium, were discovered also at other settlements in the Ljubljansko barje (Velušček and Greif 1998). It appears that the Ljubljansko barje already functioned as an important metallurgical centre in the fourth millennium. Small necklace ringlets made of a mineral which can be found far away from Ljubljansko barje in areas rich in copper ore hint as to where they mined copper. Analyses of the minerals lead us north to the Alps. A fragment of a ray bone found in the cultural layer of

Hočevarica indicates that they also maintained contact with populations living along the sea coast (the Adriatic Sea) approximately 100 km away.

Pottery production in this period also exhibits change. Reduction-baked pottery of dark shades prevails in the Ljubljansko barje during this period. The charred remains of barley and wheat permit the conclusion that this population farmed. They also bred domestic animals: mainly pigs, but also cattle, sheep, goats and dogs. A yew bow measuring 120 cm was discovered at Hočevarica; it is the only such find in Slovenia and it evidences archery and hunting with bows and arrows. Prior to the discovery of this find, all conclusions were drawn from the numerous stone arrowheads that were found in almost all settlements dating to the fifth and through to the third millennium BC throughout the entire Slovenian territory. There are many doe and stag bones among the remains of game, and apparently wild boar was also popular. Ducks and geese were prevalent among the birds, in particular species that prefer an aquatic biotope. The abundant remains of fish bones indicate that slow-flowing and still-water fish were prevalent in the Ljubljansko barje (carp, rudd, bass, sheat-fish, pike), which were most probably caught in the then lake.

In the second half of the fourth millennium BC a minor pile dwelling settlement stood not far from Ig, referred to as Maharski prekop after the nearby drainage canal. Several years of excavations at Maharski prekop yielded the ground plan of what was at the time probably a typical settlement (Bregant 1974a, 1974b, 1975, 1996). It appears to be a small, compact, but well-planned group of houses, protected from the mainland side by a palisade of vertical poles.

In the area of Stare Gmajne near Verd two oak dugouts and a wooden wheel and axle were discovered in a pile dwelling settlement from approximately the same period as those at Maharski prekop. Although this was the first discovery of dugouts from a pile dwelling settlement after 120 years, the excavators were much more impressed by the wooden wheel and axle. The wheel, with a diameter of 72 cm, is constructed from two ash boards joined together by four oak battens (Figure 5.3). The opening for the axle is square and corresponds to the end of the fully preserved 120-cm long oak axle. Similar wheels of approximately the same age have to date been found only in Switzerland and in south-western Germany. Since the axle turned with the wheel, this wheel was presumably intended for a two-wheeled cart, which would be the most suitable type for the hilly land at the foot of the Alps (Haüsler 1994).

Recent research points towards the occurrence of another hiatus, lasting several centuries, in the settlement of the Ljubljansko barje towards the end of the fourth millennium. A possible explanation for this occupational gap could be found in the diminishing interest in copper, a trend that gives an important mark to the late fourth millennium in Central Europe (Velušček and Greif 1998). Or perhaps it could also be the result of a natural disaster of major proportions (Baille 1995). We now know that pile dwelling settlements reappear in the Ljubljansko barje in the end of the twenty-ninth and during the twenty-eighth centuries BC. Dendrochronological research, radiocarbon analysis and

Figure 5.3 Wooden wheel; Stare Gmajne, second half of the fourth millennium BC. Photograph: Marko Zaplatil, Inštitut za arheologijo ZRC SAZU.

typological analysis of pottery finds all point to a more or less continuous settlement up to the twenty-fourth century BC.

Not long ago, the material finds from this period were attributed to the Vučedol culture (Dimitrijevič 1977–8; Parzinger 1984); this culture developed in the area of eastern Slavonia along the Danube River, the eastern part of present-day Croatia, during the first half of the third millennium BC. The main characteristic of this culture was its highly developed copper metallurgy and the invention of the so-called block-mould. This mould ostensibly enabled the production of several tools from the same mould, which increased the consumption of copper ore. It was the search for new copper mines that drove the 'Vučedol' people to the Ljubljansko barje, towards the mid-third millennium BC (Durman 1983).

The current belief is that the culture in the Ljubljansko barje developed parallel to the Vučedol culture, rather than being a part of it. Due to the analogous, although not quite similar, pottery forms and the highly developed copper metallurgy, which is well documented by the third millennium BC material finds from the Ljubljansko barje, it seems more plausible that there was lively communication between these populations, possibly also trade, which is consequently also reflected in the material culture.

Dendrochronological research revealed that pile dwelling settlements existed on several locations in the Ljubljansko barje simultaneously during this period. The settlements at Parte near Ig and Založnica near Kamnik pod Krimom, which co-existed for about 40 years (see Figure 5.1), are a good example.

Settlement remains dating to the first half of the third millennium BC were found in the Iščica stream along the far eastern edge of Dežman's pile dwellings (Velušček *et al.* 2000). Dendrochronological analysis of the wood from a group of several hundred vertical piles at one location revealed active construction work through an extended period. The confirmation of the existence of small rectangular buildings proved even more significant. Slovenian researchers had imagined, in the spirit of a romantic picture of the pile dwelling (Greif 1997), the existence of large pile dwelling platforms upon which the houses were erected (Bregant 1996).

The most attractive finds from the third millennium BC were found by Dežman in the second half of the nineteenth century (Korošec and Korošec 1969). Certainly the most exceptional are the creatively decorated pottery vessels, among which the most outstanding are the vessels on cruciform stems and a hollow cult vessel in the form of a human figure wearing clothing with a clearly visible pattern (Figure 5.4). There were also numerous bone, horn and stone tools among the finds. Copper axes, daggers and needles are just as captivating as the single and block-moulds and the crucibles. Obviously the Ljubljansko barje had, for the second time in its history, again become an important metallurgical centre again during this period.

Another radical change in the settlement and cultural picture of the Ljubljansko barje occurred during the twenty-fourth century. The Eneolithic period was over. It could be that this had again been caused by a natural disaster (Baille 1995). We know of only one settlement, probably still of pile dwellings, in the Ljubljansko barje from the second half of the third millennium (Dirjec 1991), in which we find rough pottery similar to the early Bronze Age cultures in the Pannonian plain, Istria and in some cave sites in Slovenia.

Human occupation of in the Ljubljansko barje ends with only a few individual finds from the second millennium BC, also discovered by Dežman. These are the so-called 'Litzen' pottery and dagger similar to a Sauerbrunn-type sword. Quite possibly these finds announce the last prehistoric settlements in the Marsh. Reliable data on the matter are lacking; however it is known that by the end of the second millennium BC, settlement moved to surrounding dry grounds and later to dominant high grounds around the Ljubljansko barje (Vuga 1980). We also know that by this time, the late second and first millennium BC, the area that was formerly a lake during the pile dwelling period had probably become mainly an impassable swamp.

Figure 5.4 Anthropomorphic vessel, 'Dežman's pile-dwellings,' first half of the third millennium BC. Photograph: Tomaž Lauko, Inštitut za arheologijo ZRC SAZU.

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6

150 YEARS OF LAKE-DWELLING RESEARCH IN NORTHERN ITALY

Franco Marzatico

Introduction

The 'pioneers'

The identification of settlements of the pile dwelling type (*palafitte* in Italian) and the initial development of their research in northern Italy date back to the second half of the eighteenth century, between the end of the 'romantic dawning' of pre-protohistoric studies in Italy and the period of the 'Founders', following the historical distinctions made by Renato Peroni (Fasani 1982: 33; Aspes 1992: 34–6; Peroni 1992: 9–41; Guidi and Bellintani 1996: 169–74, 188–97; Aspes 1997: 56–7). This kind of settlement received increased attention as a direct consequence of the interest that had been stimulated by the discoveries of the 'fields of piles' in Swiss lakes, and the theory developed by Ferdinand Keller in 1854.

The first 50 years which followed the Ober-Meilen discovery was a period of very intense exploitation of the peat bogs in northern Italy. Despite causing a serious depletion of the archaeological and natural deposits (as for instance in the case of the completely excavated peat bogs of Avigliana and Trana near Turin) (Fozzati 1982a: 122–3), this pile dwelling 'rush' nevertheless led to the identification of dozens of settlements, from Piedmont to Lombardy, to Veneto, to Trentino (Aspes 1992: 34–6; Guidi and Bellintani 1996: 169–74, 188–97).

Among the sites of greatest importance in this field of study, and in chronological order of their discovery, we first come across Peschiera (Verona). This site was discovered as a result of the construction work carried out by the Austrian Military Engineering Corps in 1850 and ten years later it was officially recognized as a pile dwelling. The Peschiera area is renowned for its numerous bronze objects, among which there were different typologies of daggers and fibulas of the violin arch type which are indeed named after this site. In the first half of the twentieth century, the term 'Peschiera horizon', which was used to identify a general style of metal objects from the Late Bronze Age and the beginning of the Final Bronze Age, became widespread throughout Italy, the Aegean area and central Europe. This phenomenon of trans-cultural circulation is today called the 'metallurgical koinè' (Carancini and Peroni 1997: 599; Fasani 2002: 112).

There are other important sites to be noted. First of all, at the Brabbia Marsh (Varese), where, starting in 1856, the brothers Quaglia gathered a collection of artefacts, which received awards at the exhibitions in Varese in 1871 and in Como in 1881. Another site to note is Bosisio Parini (Como). The abbot Antonio Stoppani was interested in this site from the beginning of 1856 and he collaborated with the Swiss researchers Edouard Desor and Gabriel De Mortillet. These two scholars also took part in the investigations at the Isolino Virginia (Varese) from 1863 (De Marinis 1982: 71–2).

In the peat bog of Mercurago (Novara), the research was undertaken by Bartolomeo Gastaldi from Piedmont in 1860. He was a person of prime importance for Italian palaethnology, and he also collaborated with Swiss colleagues (Fozzati and Fedele 1983–4: 19–20; Peroni 1992: 15–16; Mutti 1993: 18–20; Desittere 1997: 59). The scientific interest of the geologist Gastaldi was directed not only to the peat bogs and lakes of Piedmont and Lombardy, but also to the *marniere*, e.g. organic deposits with traces of human habitations found, in the Po Plain. They were widely used as fertilizers and it was indeed the local farmers that named them *marniere* or *terramare* (Mutti 1993: 17–25; Bernabò Brea *et al.* 1997: 24–5; Peroni 1992: 14–15).

The *terramare* settlements are usually situated near water courses and they date from the Middle to Late Bronze Age (*c.* 1600–1200 BC). They are mostly quadrangular in shape, with an embankment and moat where it has been possible to confirm the presence of houses on elevated platforms on piles in a dry, but also sometimes wet, environment (Bernabò Brea *et al.* 1997: 25). According to De Marinis (2000: 187), these settlements can be considered as 'pile dwellings on dry land'. The studies of Gastaldi had a very positive influence (especially for the interpretation of the *terramare* phenomenon) on Pellegrino Strobel, professor of Natural Sciences at Parma University, who was assisted by Luigi Pigorini, a young student and numismatic cataloguer, who was soon to make his mark in the field of Italian palaethnology (Peroni 1992: 15–20; Mutti 1993: 16–19; Peroni 1996a: 19–20). In 1862, Strobel announced the identification of a pile dwelling in the *terramara* of Castione di Marchesi (Parma) and, together with Pigorini, wrote an appendix on the *terramare* sites.

Whilst the scientists of the eighteenth and the first half of nineteenth century had considered the *terramare* to be the remains of sacrificial or funeral areas used by Gauls and Romans, Strobel and Pigorini, abandoning the hypothesis of Gastaldi, interpreted these remains as prehistoric settlements (Peroni 1992: 14–15; Mutti 1993: 18–20). Pigorini developed his theory from the work of the priest Gaetano Chierici linking, in an ethnic sense, the pile dwelling phenomenon and the *terramare* with 'the rites and the myths' of the Roman culture (Peroni 1992: 31–2; Peroni 1996b: 19; Desittere 1997: 63). He argued that during the Bronze Age, the Indo-European pile dwelling settlers of the Alpine lakes must have migrated southwards, building the pile dwellings found in Piedmont and mid-western Lombardy. At the same time, other trans-Alpine settlers moved to Veneto and then crossed the Po, developing the settlements of the *terramare* type. Subsequently, the descendants of these settlers possibly crossed the Apennines to create the Villanova and Latium cultures (Peroni 1992: 31–2; Mutti 1993: 22, 24; Peroni 1996b: 19). The correlation between the *terramare* and Rome was based on the supposed analogies involving the quadrangular form of the settlements, the presence of the moat and embankment, the orientation and the dimensions, the internal orthogonal layout of roads and construction and by the supposed presence of a *templum* and an *arce* in the *terramara*, considered to be 'the origin of the *forum* and *praetorium*' (Mutti 1993: 25).

Another important stage in the history of lake-dwelling research is the discovery of the peat bogs of Iseo (Brescia) and Pizzo Bodio (Varese) in 1863. A year later, two more settlements were discovered on Lake of Monate (Varese) and at Bor di Pacengo on the Lake Garda (Verona). This last pile dwelling was cited in 1967 by Alessandra Aspes and Leone Fasani (1991–2) as a reference site for the definition of a horizon of the initial Middle Bronze Age in north-east Italy, followed by the horizon of the Isolone del Mincio near Mantua (Aspes and Borghesani 1982: 180–2; Guerreschi 1982b: 201–5).

Continuing the list of the most famous sites, archaeological remains came to light at the peat bog of Feniletto (Verona) in 1869. A subsequent survey carried out in 1918 resulted in the discovery of over 225 piles arranged in irregular rows with a north-south orientation. In 1870 and in 1875 archaeological evidence was also gathered, respectively, from La Lagozzetta and the Lagozza of Besnate (Varese): the latter has given its name to a 'facies' of the Recent Neolithic period identified by Pia Laviosa Zambotti (Guerreschi 1982a: 148–50; Palazzi 2002). At about the same time, specifically in 1872, in a small inframorainic basin a few kilometres away from Lake Garda, the pile dwelling of Polada (De Marinis 2000: 11–26) was discovered by Giovanni Rambotti. It is indeed the Early Bonze Age site of Polada that coincides with the great spread of pile dwellings. This culture is documented between *c.* 2200 and 1600 BC in northern Italy, from the lake of Pusiano in Lombardy up to the Berici Mountains and to Colli Euganei in Veneto. Three further discoveries were made: Cattaragna in 1873, Bande Cavriana (Mantua) in 1878 and Arquà Petrarca (Padua) in 1885. A year before, Paolo Orsi, one of the 'fathers' of Italian archaeology (Barbanera 1998: 80–2), confirmed that the finds gathered from the peat bog of Fiavé (Trento) in 1853 were definitely evidence of a pile dwelling. This site subsequently became a milestone of wetland archaeological research in central Europe.

Research from the twentieth century to the present

As has been pointed out by Aspes as well as other scholars, the first 'pioneer' phase of pile dwelling research was characterized by a strong exploratory impulse in the investigations, which was followed by a period of stasis in the first half of the twentieth century (Aspes 1992: 36; Guidi and Bellintani 1996: 172, 191).

In this period of reduced levels of discovery and research, one can nevertheless note the studies carried out at Arquà Petrarca (Padua), on the small lake of Frassino (Verona); on the Isolino di Varese in the first decade of the twentieth century; at Feniletto (Verona) in 1918; at Barche di Solferino (Mantua) between 1939 and 1940; at the pile dwelling of Cisano along the east shore of Lake Garda (Verona) in 1926, 1938 and 1940; and finally, at the pile dwelling of Molina di Ledro (Trento) in 1929 and 1937, where Raffaello Battaglia, quickly exploring 4,500 square metres of the site, recorded the presence of more than 10,000 piles. It remains to be determined to what extent the stratigraphical findings at Ledro can be taken as a basis of reference in distinguishing the phases in the Bronze Age. While Gianluigi Carancini and Renato Peroni (1999: 11) acknowledge in the Ledro data a certain level of reliability, De Marinis, on the other hand, underlines some problematic aspects regarding the definition of the Bronze Age phases in northern Italy (De Marinis 1999: 36).

From the Second World War to the 1980s, it is possible to identify a renewed interest in the investigation of wetland sites, with new research carried out at sites already known, such as the Isolino Virginia (Varese), Lagozzetta (Varese), Lagazzi (Cremona), Cisano (Verona), Isolone del Mincio (Mantua), Lavagnone (Brescia), Bande di Cavriana (Mantua), Lucone (Brescia), Ledro (Trento), Fiavé (Trento), Fimon Molino Casarotto (Vicenza), Peschiera (Verona), La Quercia di Lazise (Verona) (Aspes 1992; Aspes *et al.* 1995: 295). New sites were subsequently discovered at Laghetto del Frassino (Verona) in 1957, Palù di Livenza (Pordenone) in 1965, Corno di Sotto (Brescia) in 1966, Canàr (Rovigo) in 1970, the submerged pile dwellings of Viverone (Turin) in 1971 (Fozzati 1982b: 123–5; Fozzati and Fedele 1983–4; Gambari 1997), La Maraschina (Brescia) and Gabbiano di Manerba (Brescia) both in 1971, Castellaro Lagusello (Mantua) which came to light in 1977, Moniga (Brescia) in 1978 and finally, Cà Nova di Cavaion Veronese (Verona) discovered in 1980. Fresh research incentive came with the establishment of the STAS (the Technical Services for Underwater Archaeology) in 1986.

Fiavé: chronology and material culture

Thanks to the extraordinary level of preservation of the wooden structures, and the cultural, paleo-botanical and natural history remains and to the extensive nature of the stratigraphical investigations, as well as to the attention paid to the paleo-environmental aspects, the excavations carried out in the peat bog of Fiavé between 1969 and 1976, have assumed without any doubt a position of absolute prime importance and are a stimulus for Italian archaeological research into the wetlands (Perini 1984, 1987, 1994). The site offers the richest series of archaeological finds with verified stratigraphical provenance and an extraordinary record of building solutions adopted at successive times or simultaneously in topographically differentiated areas. Bronze Age wooden artefacts such as a yoke, a plough, a saw, a sickle (Figure 6.1), baskets, a bow, headgear and numerous containers, constitute the most comprehensive collection of wooden objects in Italy (Perini 1988a).

After sporadic evidence of human presence in the Mesolithic Period (Brochier *et al.* 1993), a first phase of habitation in the peat bog of Fiavé occurred in the

Figure 6.1 Middle Bronze Age sickle with wooden handle and flint blade from pile dwelling of Fiavé, Trentino, Fiavé 6 horizon. After Perini 1994.

Late Neolithic – named Fiavé 1 – (Pedrotti 2001: 162–4). This phase corresponded to the construction of huts along the bank of an islet (Zone 1). The huts had a base consisting of gravel and stones covering organic material inserted into the spaces between tree trunks, arranged in a regular manner along the sloping bank of clay. After a period of human habitation in the same area at the beginning of the Early Bronze Age (Fiavé 2) – named Zone 2 (Figure 6.2, top) – the foundation of an Early Bronze Age pile dwelling village (Fiavé 3) begins in an adjacent inlet. Its foundations consist of dozens of individual piles, without braces, obtained from coniferous trunks, with a total length of about 9–10 m (Figure 6.2, bottom) and set in the ancient lake bed to a depth of about 4–5 m. A similar habitation nucleus located nearby (Zone 4) also dates back to the end of the Early Bronze Age (Marzatico 1996). Since dendrochronological analysis did not produce any useful information, it has not been possible to establish if this inhabited area was contemporary with that of Zone 2, which yielded the same pottery typologies. It has been confirmed that the occupation of the inhabited area of Zone 2 continued up to the middle phase of the Middle Bronze Age (Fiavé 5). In the next phase of the Middle Bronze Age (Fiavé 6), this settlement was abandoned together with the settlement in Zone 1, which had already been settled in the Late Neolithic. This settlement was surrounded by a palisade close to the small lake, at that time 4–5 m deep. The inhabited area is characterized by an ingenious foundation system, constructed according to a preordained plan that suggests the existence of privileged people, in a position to organize and control the complex work.

The foundations of Fiavé 6, along the bank and on the bed of the lake, consist of vertically pierced boards, i.e. with holes where the tie slats are located. They served to hold a grid foundation on the lake bottom and lay at right angles to

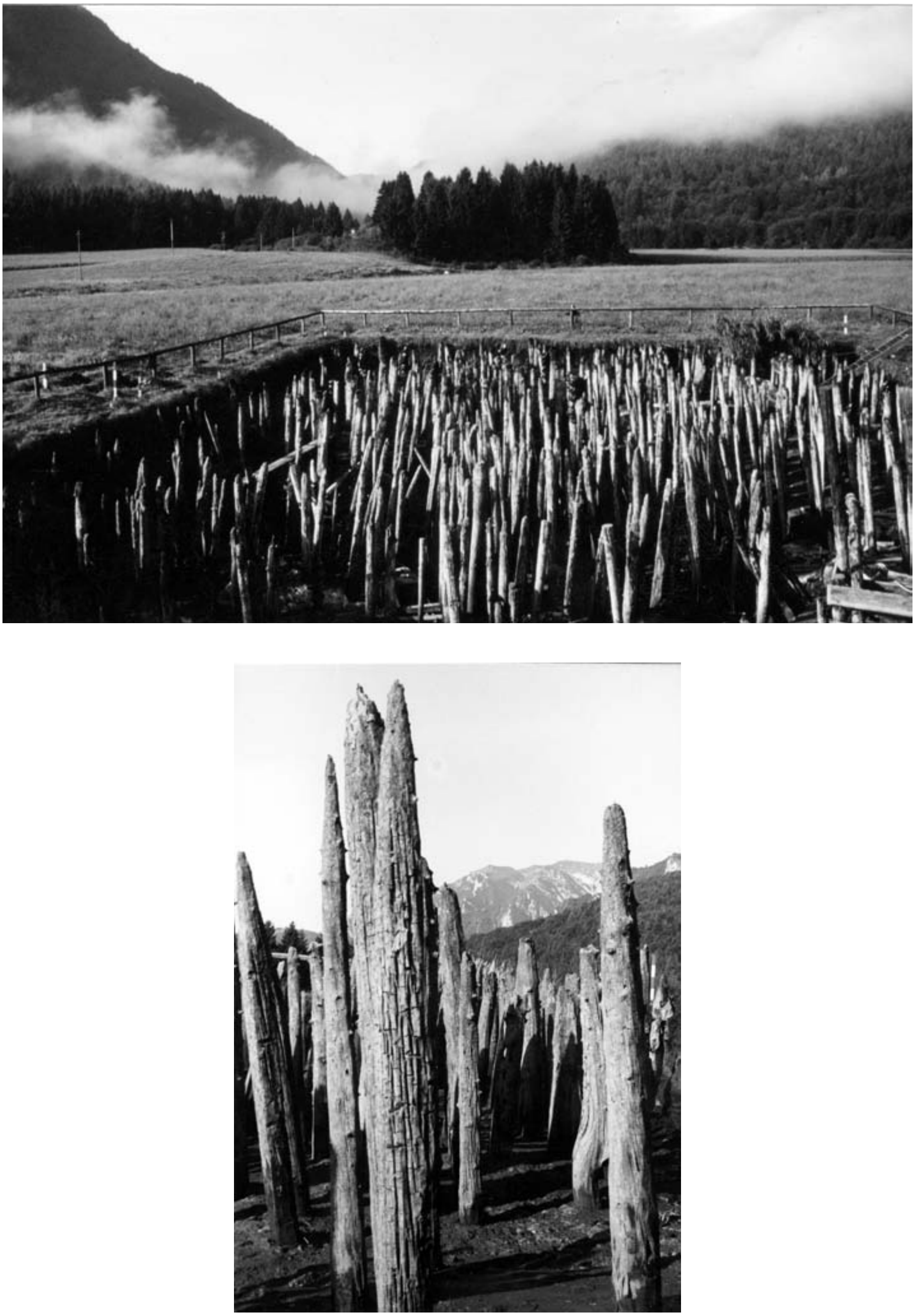
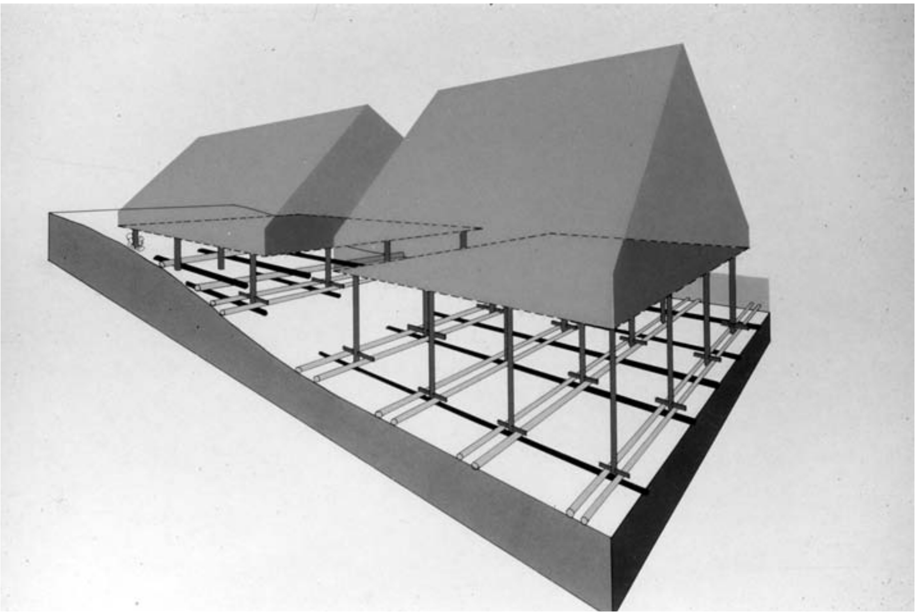


Figure 6.2 Top: view of the foundations discovered in the zone 2 of Fiavé, Trentino. Bottom: nine-metre long piles in zone 2 of the lake settlement of Fiavé, Trentino. After Perini 1984.

each other, in order to distribute in regular manner the weight of the huts standing above (Figure 6.3, top). Recently, a relationship between the construction methods at Fiavé 6 and those of the Early Bronze Age site at Bodman-Schachen in the western area of Lake Constance has been proposed by Joachim Köninger and Helmut Schlichtherle (2001: 45). These two scholars argue that the exchange of technological knowledge shows extensive contact between the trans-Alpine and southern Alpine areas. In fact, construction methods which were very common on Lake Constance and in East Switzerland during the Arbon Culture (Early Bronze Age) can also be found in the Lake Garda area (Königer and Schlichtherle 2001: 45). The settlement of Fiavé 6 demonstrates the coexistence of



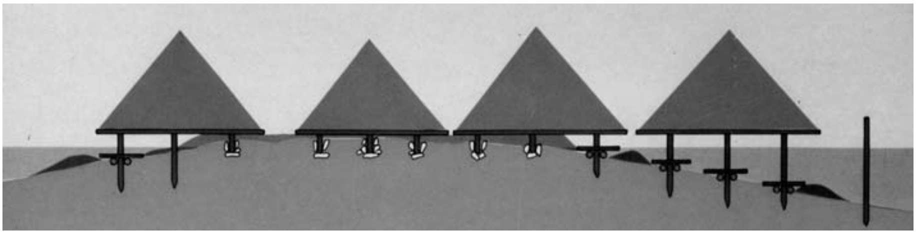


Figure 6.3 Top: Fiavé: reconstruction of the pile foundation with base grid of the Middle Bronze Age village – Fiavé 6. Bottom: reconstruction of the building solutions adopted simultaneously at the end of the Middle Bronze Age – Fiavé 6. After Perini 1984.

different building typologies, with a remarkable capacity for adaptation to varying geomorphologic conditions. Along the peninsula bank, the use of ingenious pile grating, used to support the elevated floors of the huts, has been identified, but, at the same time, on the summit of the peninsula houses were built with the floors at ground level (Figure 6.3, bottom).

The investigations at Fiavé attracted the interest of a number of international scholars. In fact, a second phase of archaeological exploration, which started in the 1980s (and is still ongoing), has seen the involvement of Swiss, French, German and English researchers in projects that aim to explore the relationships between the series of settlements and the paleo-environmental aspects in an interdisciplinary way (Brochier *et al.* 1993; Marzatico 2003: 95).

Lavagnone

Another pile dwelling settlement of fundamental importance is that of Lavagnone near Desenzano (Brescia), situated on the shores of a small lake in a morainic amphitheatre not far from Lake Garda. The systematic research, carried out by Renato Perini between 1974 and 1979 and by Raffaele Carlo De Marinis has resulted in the identification of various building phases and the assemblage of a sequence of material which constitutes the main point of reference for distinguishing the phases of the Early Bronze Age – the Polada culture (Perini 1975–80, 1988b; De Marinis 2000: 90–2, 95–8). There are disagreements between these authors regarding attribution in terms of the relative chronology. First, the ceramic horizon called Lavagnone 4, according to Perini, corresponds to the beginning of the Middle Bronze Age, whereas according to De Marinis it is attributable to a late phase of the Early Bronze Age. There are also differences relating to the chronological ceramic horizons of the Middle Bronze Age itself (Perini 1975–80: 137–48; De Marinis *et al.* 1996: 267–8; De Marinis 2000: 95–8).

Among the wooden artefacts from the Early Bronze Age there is a yoke and a remarkable plough with a 2.20-metre-long interchangeable plough-stilt (Figure 6.4) (Perini 1983). Of great interest is the neighbouring discovery of another whole plough-stilt, which was probably a spare part, ready to use in case of damage. This component was certainly subject to heavy stress, with the risk of frequent breakages. The plough-stock has two interchangeable parallel slots on the lower part that probably served to join the wooden 'blade' or 'sliding block' (Perini 1982: 151–71; Perini 1983: 187–95). The oldest phase of the settlement (about 2050 BC) dates back to the beginnings of the Polada Culture. The pile dwelling, built in a flat area of bog and turf, was reached via a timber trackway, which consisted of interlaced branches placed on the turf surface and consolidated by vertical piles (De Marinis 2000: 100). The settlement of Lavagnone 2, which was occupied for about 65 years, was also surrounded by a palisade (De Marinis 2000: 103). The development of a new building phase (Lavagnone 3) is dated to 1984 BC. This phase is characterized by the use of racket-type plinth piles, intended to prevent the piles sinking further into the remains of the earlier

Figure 6.4 The Early Bronze Age wooden plough found in the pile dwelling of Lavagnone (Lombardy). After Perini 1982.

settlement (Salzani 2002: 110; De Marinis 2000: 108–9). New settlements were subsequently constructed on reclaimed sandy mud (Lavagnone 4) and on dry ground (Lavagnone 5, 6) (De Marinis 2000: 119–57).

Lake Garda and surroundings

Of particular interest are the excavations directed by Alessandra Aspes at the submerged Bronze Age pile dwelling of La Quercia di Lazise (Verona) on Lake Garda (Aspes 1987: 81–5, 92); the Late Neolithic site of Palù di Livenza (Pordenone) excavated by Serena Vitri (Vitri 2001: 83–101) and the wetland site of Colmaggiore di Tarzo and that of the lakes of Revine (Treviso) researched by Elodia Bianchin Citton (2001). These last two sites were occupied at the end of the Neolithic, with cultural elements from the end of the third phase of the Square Rim Vase Culture and the Lagozza Culture. Excavations carried out by Luciano Salzani in 1984 brought about the discovery of the Early Bronze Age/ Middle Bronze Age settlement of Canàr in the Valli Grandi Veronesi. An important aspect is the cultural significance of this settlement which, together with elements of the Polada Culture, has brought to light a considerable number of ceramic types analogous to those of the mid-Danubian cultures of Wieselburg-Gàta (Bellintani 1998: 17).

Innovative palaeo-environmental analyses and multi-disciplinary research was carried out by Leone Fasani at the pile dwellings of Castellaro Lagusello (Mantua) in the 1990s (Cattani and Carra 2002). Similar interdisciplinary studies have provided the incentive for the new phase of research in *terramare*, which started in the mid-1980s. In particular, this is due to the work of Maria Bernabò Brea, Andrea Cardarelli and Mauro Cremaschi who, together with various collaborators, carried out a review of old museum collections, and initiated new excavations at the *terramare* of S. Rosa near Poviglio (Reggio Emilia) (Bernabò Brea *et al.* 1997: 23). Research projects still in progress include the *terramare* situated in the southern Valli Grandi Veronesi (Balista and De Guio 1996: 137–60), at Cà de Cessi (Mantua) (De Marinis *et al*. 1994) and at Castellaro del Vhò near Piadena (Cremona).

This new period of investigations has also enabled archaeologists to link the pile dwelling phenomenon to the *terramare* and, although there are still major gaps in knowledge and conflicting interpretations, scholars are more and more aware of their importance in shedding some light on the prehistory of northern Italy and the Alpine region in general (De Marinis *et al*. 1994: 93–6; De Marinis 1997; Carancini and Peroni 1999).

Conclusions

From a spatial-distributional point of view, the northern Italian lake-dwellings cover an area that goes from Piedmont to Friuli Venezia Giulia including Lombardy, Emilia Romagna, Veneto and Trentino. These are mainly located near the shores of pre-Alpine lakes, the small basins of infra-morainic lakes and, to a lesser extent, near river depressions and in the middle and lower areas of the plain (Aspes 1992: 36–7; Balista and Cremaschi 1991–2: 157–8; Guidi and Bellintani 1996: 174, 197–208; Balista and Leonardi 1996: 203; De Marinis 2000: 187). The main concentration of evidence comes from the Lake Garda area and its shores, with about a hundred inhabited sites.

As far as chronology is concerned, human presence in the wetlands of northern Italy started in the Upper Palaeolithic and Mesolithic, as is documented by the peat bog of the Palughetto, on the plain of Cansiglio (Veneto), Palù di Livenza in the Friuli region (Peresani and Ravazzi 2001: 35–6, 44–50; Vitri 2001: 91) and at Fiavé (Brochier *et al.* 1993). Wetland settlements intensified during the Early Neolithic, but the most significant evidence comes from the Middle Neolithic (the Square Rim Vase Culture).

At one point, Fasani argued that the intensification of pile dwellings during the Bronze Age had its roots in the Neolithic culture of Lagozza together with the final phase of the Square Rim Vase Culture (Fasani 2002: 108). However, he has recently stated that there is discontinuity in the 'native tradition' between the end of the Neolithic and the Early Bronze Age when, with the arrival of the Polada Culture, we have an increase in pile dwelling occupation on the Lake Garda basin around 2050–2010 BC (Fasani 2002: 108). Fasani finally concludes that the development of the pile dwellings in the Lake Garda region during the Early Bronze Age is probably associated with the arrival of new settlers from the mid-Danubian region (Bellintani 1998: 17; Fasani 2002: 108–9).

These considerations bring us back to the still open debate about the chronological development of the pile dwellings in the southern parts of the Alps. The phenomenon started in the Neolithic, flourished in the Early Bronze Age and ended towards the end of the Late Bronze Age (about 1200 BC). The end of the pile dwelling phenomenon also coincides with the disappearance of the *terramare* and the depopulation of large areas of the Po Plain (Bernabò Brea *et al.* 1997: 28–9; De Marinis 1997: 417–19).

Scholars generally agree that the flourishing of pile dwellings could be related to a specific response to environmental conditions and an unprecedented demographic increase (Fasani 2002: 108–9) which, following an increasing demand for food production, would have found a solution in the occupation of the lakeside areas, favourable to agricultural and animal breeding (De Marinis 2000: 183). At the same time though, because of the various differences between cultural and environmental contexts, such generalizations could be misleading (Riedel 1996: 71–6; De Grossi Mazzorin and Frezza 1998; Riedel 1998).

It would be very important to know more about the level of social complexity reached by the communities (both pile dwellings and the *terramare*). The construction of these wetland agglomerates sometimes shows some forms of complex planning, which could only have been done by a well-organized society, with perhaps a pyramidal social structure (Fasani 2002: 108). Unfortunately this kind of information is very hard to find. The lack of human remains and burial grounds, makes it almost impossible to detect any social structure within those wetland social groups (Aspes 1992: 42; Guidi and Bellintani 1996: 223–4; De Marinis 2000: 188; Fasani 2002: 109, 112).

Despite the fact that a lot of work has been done, and a great amount of information has been obtained, we still cannot answer important questions about various aspects of the pile dwelling and *terramare* phenomenon in northern Italy. The multi-disciplinary orientation of the latest research and the international involvement of various scholars will definitely contribute to improving our knowledge on this fascinating topic, which is crucial for a better understanding of Italian as well as central European prehistory.

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7

THE DEVELOPMENT OF WETLAND ARCHAEOLOGY IN BRITAIN

Bryony Coles

Introduction

Britain, with its long coastline and complex history of rise and fall in relative sea-levels, has a rich heritage preserved in both its inland and coastal wetlands. Sites and landscapes dating from the Early Palaeolithic to recent times have been preserved, to become the focus of an approach to wetland archaeology which is distinguished by its concern for past environments as well as people, and which exploits the extraordinary preservation of evidence in wetlands to enlarge our understanding of the past as a whole. Wetland archaeology includes the investigation of landscapes drowned by the rising sea, but not the investigation of things pertaining to the open sea, which is more properly the province of maritime archaeology and not covered in the present discussion. The following pages will trace the development of the British approach to wetland archaeology, concentrating on the events and influences and some of the classic excavations which have contributed to the present character and status of wetland archaeology in this country. It will become apparent that external matters such as the history of land drainage and of development have had a significant influence, alongside the dramatic archaeological developments in Switzerland in the mid-nineteenth century and developments within the discipline of archaeology as a whole.

Early years

An interest in Britain's standing monuments as relics of the past can be traced back to the late medieval period, with understanding of their significance growing from the late sixteenth century onwards. Soon, those who were interested in the past began to appreciate that evidence could be buried below the ground with little or no surface manifestation, as can be seen with John Aubrey's comment in the mid-to-late seventeenth century that 'one may discerne in the corne ground the sign of the streetes' of the Roman city of Silchester (Britton 1847: 37). This understanding was essential for the development of wetland archaeology, where there is rarely any artificial mound or collapsed wall or grassy rampart to indicate the former activities of people. By the time of the agricultural improvements of the mid-eighteenth century, when there was a marked expansion of land drainage and conversion of wetlands to arable and pasture in order to feed a growing and increasingly urbanized population, many people working on the land were aware that objects and structures retrieved from below the surface of wetlands could belong to former times. In some cases, they may have made a connection with the Biblical account of Noah and the Flood, and assumed their discoveries were relics of this catastrophic event.

Soon after Britain's increasing interest in antiquities was marked by the foundation of the British Museum in 1759, a man who was digging peat in Oakhanger Moss in Cheshire came across a wooden carving. The rector of the parish later wrote the following account of the man and his discovery:

> Daniel Stringer was another worthy of this township. . . . He was a man, both in talent and information, far in advance of his own class, and only wanted education and opportunity to become a distinguished character. . . . He was digging, when a young man, in one of the Oakhanger mosses, and, at a great depth, hit upon a wooden figure, rude and grotesque, but complete with eyes, nose and mouth. He concluded it to be an *idol*, and sent it to the British Museum with an account of its discovery, but never learnt whether it arrived safe there.
>
> (Hinchliffe 1856: 116–17)

It is interesting to learn from this that Stringer knew of the British Museum although it had been in existence only a few years when he discovered the wooden carving, and that he thought to send his find there. There is, however, no record of the British Museum ever having received it.

There are a number of similar records from the late eighteenth and early nineteenth centuries which describe curiosities and antiquities found during peat cutting or drainage. As time passed, these were more and more likely to be reported to a local antiquary and perhaps acquired by a local, regional or national museum. There were, for example, discoveries of dugout canoes along the Clyde in western Scotland, one of which was acquired by the Society of Antiquaries of Scotland for their own museum.

Past wetland environments

There was at the same time a growing interest in the remains of plants and animals which could be found in wetland conditions, which were also appreciated as belonging to past eras. Here the nascent science of geology with its awareness of stratigraphy, together with the popularity of investigating cave faunas, contributed to people's understanding of what they found in former lakes and river valleys, and the circumstances of discovery were often related to agricultural improvements. In the valley of the River Kennet, a tributary of the Thames, an early account of the peat deposits near the town of Newbury and of the things found therein was written by John Collett in 1756. The Kennet peat was dug for household fuel, and the ash subsequently sold to farmers for use as a fertiliser on their fields. Collett recorded the characteristic stratigraphy of basal gravel, then peat followed by peaty clay. He noted remains of trees in the peat, some of which could be identified as oak, alder, willow or fir, and remains of wild animals. There were also humanly made objects, and an urn from a probable burial mound (Peake 1937: 116–17). In eastern Scotland in 1788, the antlers of large deer and bones of beaver were found during drainage of Loch Marlee. The drainage was undertaken to obtain lake marl to improve the condition of the land for cultivation, and the discovery of the bones aroused considerable interest, particularly as beaver were by then extinct in Britain and so their remains were obviously of some antiquity, and proof of the accuracy of the old records which referred to the former presence of the species in Scotland (Wilson 1858).

There were people other than peat diggers and drainage men who observed below the wetland surfaces. Reid (1913) drew attention to the tinners of Cornwall who followed former stream beds, sometimes even working out under the present sea in their search for tin. The miners came to understand much about stream dynamics and something of the age and the environment of human artefacts found within the channel deposits. One such was J.W. Colenso who in 1829 wrote *A Description of Happy Union Tin Stream-work at Pentaun*, a site near the estuary of the St Austell River. He described a buried oak forest consisting of trees which had grown and then fallen on a former land surface and soon become buried by river deposits which he thought were built up due to rising sea-levels. In later (upper) silty levels more wood was found, and nut shells and animal bone, and a piece of worked oak. Later still, more trees had grown and their remains were preserved along with animal bone including oxen 'of a different description from any now known in Britain'. Next came one of the most intriguing discoveries, and an acute observation on the different conditions of the past:

> . . . the remains of a row of wooden piles, sharpened for the purpose of driving, which appear to have been used for forming a wooden bridge for foot passengers: they crossed the valley, and were about six feet long; their tops being about 24 feet from the present surface – just on a level with the present low water at spring tides. Had the sea-level been then as now, such a bridge would have been nearly useless.
>
> (Colenso, quoted in Reid 1913: 97)

One can but agree with Reid, who commented that 'It is a great pity that antiquaries were not at that period more alive to the great interest of these finds' (Reid 1913: 98).

The impact of Swiss discoveries

The next development was to be of great significance for archaeology as a whole. It was the recognition, in the winter of 1853–4, of the Swiss lake-dwellings or prehistoric settlements, preserved in the waterlogged deposits around the shores of the *Zürichsee* and other lakes (see Chapter 1). Widespread interest was aroused in Britain by these discoveries, particularly after John Edward Lee translated six of Ferdinand Keller's original reports into English and published them as a book entitled *The Lake-Dwellings of Switzerland and other parts of Europe.* The first edition appeared in 1866, and its popularity is indicated by the publication of an enlarged two-volume second edition in 1878. *The Lake-Dwellings of Switzerland* enabled people in Britain to appreciate something of the possible character of prehistoric settlement in their own land, different from that of the Classical Mediterranean world and from that of Roman Britain, something to set beside the defended but not necessarily occupied hillforts and beside the occupied but not necessarily typical caves and rock shelters.

The Swiss discoveries encouraged British antiquaries to search for similar lake-dwellings in their own land. In Scotland, as in Ireland, crannogs had already been recognized as lake islands made up and used for habitation in former times, and from the late 1850s there was an increased interest in the crannogs and greater realization of their possible antiquity. Early accounts by Robertson and Stuart were soon followed by Robert Munro's examination of the Lochlee crannog in Ayrshire in the late 1870s (Figure 7.1) and his publication of *Ancient Scottish Lake-Dwellings or Crannogs* in 1882. Munro had a great enthusiasm for crannogs with their good preservation of waterlogged structural and occupation evidence, and he emphasized that mundane finds such as food refuse and the broken debris of daily life were significant, and were as important for understanding the past as were finely made and well-preserved weapons and ornaments. In 1886, Munro and his wife set out on an extensive tour of Europe to study lake-dwellings, in preparation for him giving the Rhind Lectures to the Society of Antiquaries of Scotland, which were duly published as *The Lake-Dwellings of Europe* in 1890. Both the lecture series and their publication helped to stimulate further interest in Britain in wetlands as a source of evidence for study of the past.

Munro had written at length on Scottish and Irish crannogs but found little to say about English discoveries. In 1892, a young medical student made a discovery in the Somerset Levels in south-western England that was to change the situation. The student, Arthur Bulleid, had read Keller's *Lake-Dwellings* in 1888, and the descriptions of the Swiss prehistoric settlements, buried and preserved in waterlogged deposits, inspired him to search the wetlands around Glastonbury for similar sites. In 1892 his efforts were rewarded with the discovery of a Late Iron Age settlement which soon became known as the Glastonbury Lake Village. Over the next two decades, Bulleid devoted much of his life to the excavation and publication of this remarkable site, being joined in the later years by Harold St George Gray. The Glastonbury Lake Village excavations were probably the first in Britain to recognize and exploit the distinctive characteristics of wetland archaeology, and Bulleid's work, in the early years in particular, was innovative in its scientific approach and the adaptation of excavation methods to suit the wetland environment. He worked with a small, skilled group of men and opted at times for what came to be called Open Area

Figure 7.1 View of an excavation trench opened by Robert Munro at Lochlee Crannog in 1878–1879. Munro 1882: Figure 34.

excavation in order to expose the clay floors of houses and activity areas in their entirety. He himself spent hours and days in the meticulous excavation of fragile woven, wooden hurdles, and he recorded and saved the refuse of daily life, as Munro had advocated. Bulleid was in fact directly advised by Munro, who visited the site within a couple of months of its discovery, and by a committee of leading archaeologists and scientists which included, in addition to Munro, Pitt-Rivers, Baker, Boyd Dawkins and John Evans (Coles *et al*. 1992: 13). The skills of the committee were put to good use providing specialist reports which were integral to the understanding and interpretation of the site, and which formed a significant part of the two-volume site publication *The Glastonbury Lake Village* (Bulleid and Gray 1911, 1917). Baker, from the Royal Botanic Gardens at Kew, reported on plant remains, as did Clement Reid from Cambridge in the later years. Andrews, from the Natural History Museum, worked on the bird bones and Boyd Dawkins, based at Manchester Museum, examined the human remains. Gray, who was one of the first generation of professional archaeologists in Britain trained by Pitt-Rivers, introduced a greater emphasis on sections and stratigraphy and he carried out much of the study of the huge quantity of material culture from the site.

The mid-twentieth century: Clark and Godwin

It was to be some time before the standards set in the early year at Glastonbury were met in other wetland work, and even Bulleid and Gray did not really live up to them in their own subsequent work at the nearby Meare Lake Villages. However, the years between the First and Second World Wars were not entirely fallow and by the 1930s significant developments were taking place at the University of Cambridge where the young prehistorian Grahame Clark and the young ecologist Harry Godwin came together to set up the Fenland Research Committee. Clark was inspired by his knowledge of the well-preserved Mesolithic sites from the Scandinavian wetlands, and Godwin by the research of Erdtman and Von Post on pollen analysis which he and his wife Margaret Godwin began to use in British wetlands. Both Clark and Godwin saw the extensive East Anglian Fenland as an open-air laboratory on the doorstep of their university, and although we now know that more than a century of determined drainage had already damaged the deposits, they were right in their assumption that this was an ideal wetland location for long-term research on the interactions of human activity and environmental change. One of the Godwin's early uses of pollen analysis was to provide an approximate date for a bone harpoon head trawled up in 1932 from the submerged peats between the Leman and Ower banks off the Norfolk coast. The Godwins showed that the peats were of early Boreal age, although they cautiously noted that the peat directly associated with the harpoon had been jettisoned and the peat which they had analysed had been trawled up from nearby (Godwin and Godwin 1933). Later, Godwin was able to use radiocarbon dating of other early Boreal peats to give an approximate age of 6465 BC to the harpoon (Godwin 1978: Figure 7). Later still, an AMS date was to be obtained for the harpoon itself, which at 11740+/-150 BP (Housley 1991) showed the Godwins' early caution to have been justified.

Godwin's diagrams reveal how closely pollen analysis, stratigraphy and archaeological evidence were brought together in these early years, as do the diagrams from his joint work with Grahame Clark at Shippea Hill in the south-eastern Fens (Figure 7.2). The illustrations demonstrate a distinctive approach which soon came to characterize wetland archaeology in Britain, where the presence of organic materials and evidence for context and environment take equal place

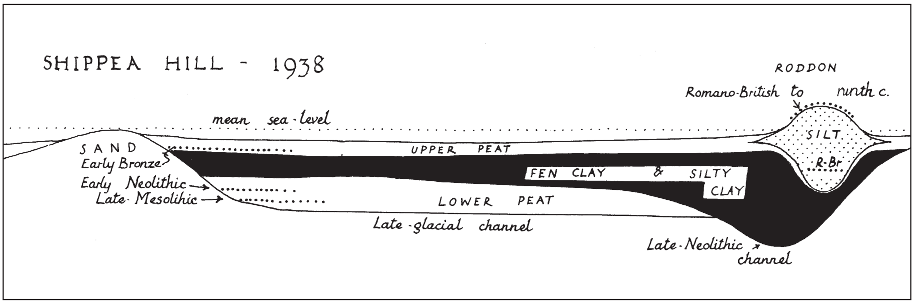

Figure 7.2 Godwin's 1938 diagram of the Shippea Hill stratigraphic sequence, showing how successive phases of human occupation relate to changes in the wetland environment of the East Anglian Fens. Based on Godwin 1978: Figure 15.

with objects, features and structures. There was an interruption to the work of the Fenland Research Committee during the war years, following which Clark and Godwin both returned to wetland work. Clark took the leading role in the investigation of Star Carr, a Mesolithic site in the Vale of Pickering in Yorkshire which was excavated in the summers of 1949, 1950 and 1951. Clark described the state of Mesolithic studies in Britain which led to development of this major inter-disciplinary research project:

> It was appreciated that the need was no longer to excavate and classify flint implements or rely upon fortuitous discoveries of loose objects of antler or bone, but to investigate a site capable of yielding direct information about the way of life of Maglemosian man and about the character of his immediate environment. This, it was recognised, was most likely to be achieved by excavating in waterlogged deposits, either in a bog settlement or immediately contiguous to a settlement on dry land, since here alone were the physical conditions necessary for the survival of a broad range of organic materials likely to exist in this part of the world.
> (Clark 1954: xxi)

The excavations exposed a former lake shore where there was an accumulation of birch branches, several pieces of worked wood including the remains of hafts and a possible paddle, rolls of birch bark, implements of bone and antler and flint and the debris from their manufacture, together with the information-rich peaty matrix in which they were preserved. In some respects, Clark may have been disappointed for there were none of the fishtraps or other elaborate organic artefacts known from the Scandinavian Mesolithic, but he made full use of all the sciences which could then be applied to wetland sites in order to draw out the maximum knowledge from the remains. Environmental analyses were carried out by Walker and Godwin from the University Sub-department of Quaternary Research at Cambridge, and faunal analyses by Fraser and King of the British

Museum (Natural History) while Clark was responsible for the excavations and analysis of the artefactual material, for the overall interpretation of the site, and for its prompt publication in 1954. His interpretations of resource exploitation and seasonality of occupation, which did much to bring the British Mesolithic to life, were characteristically conveyed through diagrams as well as the written word and these illustrations again show the close integration of archaeological and environmental evidence (Figure 7.3). There have been subsequent challenges to Clark's interpretation of Star Carr as a winter camp, and a number of re-interpretations including one by Clark himself (1972) which in their own way reflect the development of archaeology in the latter half of the twentieth century. Clark's genius lay in recognizing the potential of the Star Carr material as a

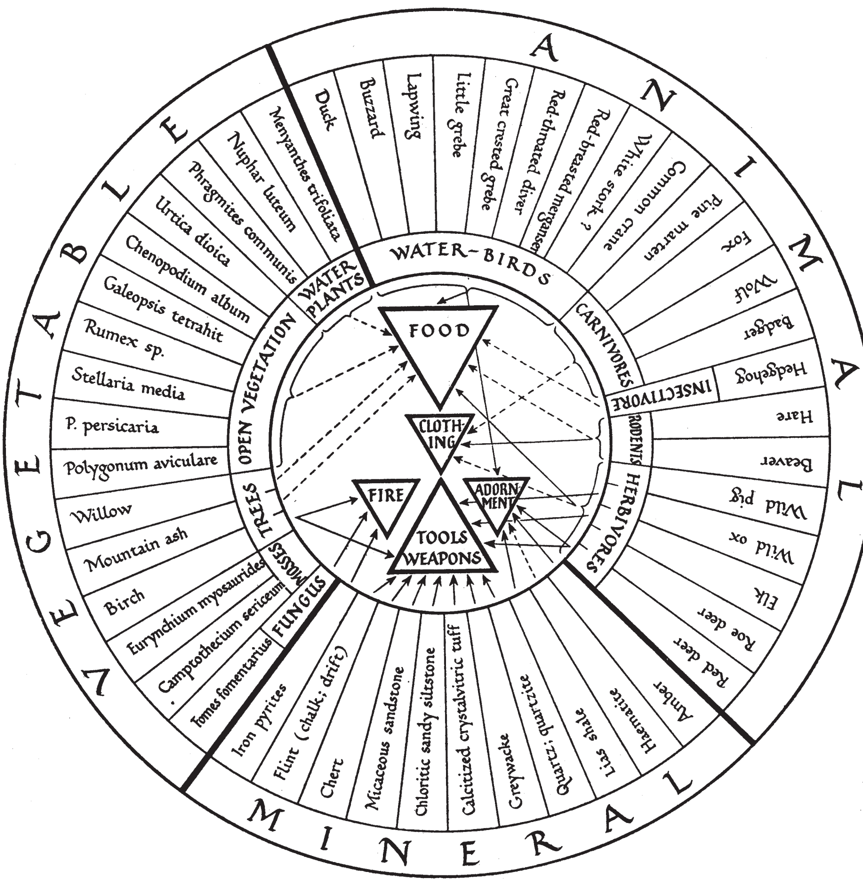

Figure 7.3 Clark's diagram of resource exploitation by the Mesolithic inhabitants of Star Carr (Clark 1953: Figure 4). The diagram was prepared to illustrate a public lecture, and was not included in the 1954 excavation report.

source of evidence, knowing whom to persuade to extract that evidence, and what to do with it once he had it. So many archaeologists working in wetlands are submerged by the data, swamped by the quantities of things and facts, that perhaps it was Clark's good fortune to choose for his major research project a site that was not overwhelmingly productive.

Godwin's major research, meanwhile, was on the use of pollen analysis to reconstruct the development of the vegetation cover of Britain through Quaternary times. At first, he continued to use artefacts stratified in peat to date the British pollen zones, for example a Bronze Age spearhead embedded in the Somerset peats. Before long, the pollen zones and peat stratigraphy were well-enough established to reverse the process in order to date cultural remains such as wooden trackways and other organic finds for which there were no dated typological sequences (Figure 7.4). The integration of archaeology and palaeoenvironmental studies in British wetland archaeology owes much to Godwin, whose work in Somerset in particular showed how the environmental and the cultural evidence could be used to support each other and to provide an understanding of the past that was more than a list of the individual components. In the later 1930s Godwin had met Bulleid at Meare, and they struck up a friendship which encouraged Godwin in his own excavations of trackways and other archaeological features; their discussions quite possibly contributed to the development of Godwin's distinctive interdisciplinary approach. His *History of the British Flora* (1956) soon became a classic work of reference, providing the framework for increasingly detailed and sophisticated investigations of vegetation change, including the recognition of human impact. The importance of this aspect of wetland research to our understanding of past cultural as well as natural evolution is sometimes underrated, perhaps because we have come to take it for granted.

Other notable wetland investigations of the mid-twentieth century include the work of Cyril Fox at Llyn Cerrig Bach on Anglesey in North Wales. This was more salvage than research as far as the fieldwork was concerned, consisting of the rescue of Iron Age votive deposits revealed when the peat from a former lake was used in the making of a war-time landing strip (Fox 1947). In Scotland C.M. Piggott (1953) carried out one of the few crannog investigations to take place in Britain in the twentieth century, while in England one of the more interesting projects to follow Star Carr was that undertaken by Wymer and Churchill at the Mesolithic site of Thatcham near Newbury in the valley of the River Kennet (Wymer 1962; Churchill 1962).

Later twentieth-century wetland surveys

In the 1960s, as Britain moved from the austerity of post-war rationing to the boom-time of 'You've never had it so good', peat came into widespread use as a horticultural medium, and the introduction of machine-cutting greatly accelerated the rate of extraction. In southern England this development affected the Somerset Levels where peat-cutting was a well-established local industry, and

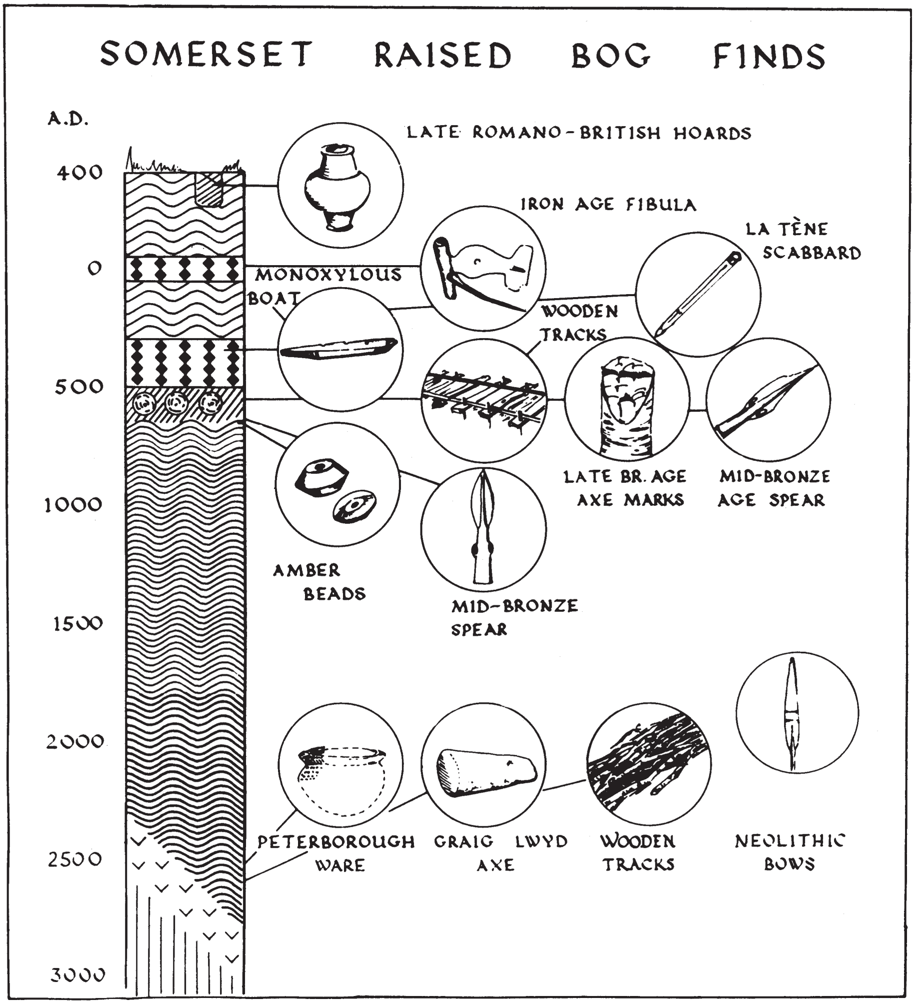

Figure 7.4 Godwin's 1951 'time correlation scheme . . . the evidence of archaeology, bog stratigraphy, pollen analysis and, behind them all, climate change, smoothly interlocks' (Godwin 1981: 129; Dewar and Godwin 1963: Figure 9).

archaeologists soon responded, with new field research begun by John Coles at the suggestion of Grahame Clark, by now Professor of Archaeology in Cambridge where Coles was a lecturer. In the Fens, so much closer at hand for Cambridge archaeologists, agriculture dominated the former wetland region and the invidious and near-invisible threat caused by drainage was recognized only a few years later, with a new impetus to archaeological investigation beginning in the mid-1970s. Thus it was in Somerset that the first major survey of a British wetland developed, directed initially by John Coles and joined later by the author as co-director.

The Somerset Levels Project, as it became known, was funded by English Heritage and its precursors to monitor the peat-cutting areas for exposures of archaeological remains, to excavate where necessary, and to carry out pollen, plant and insect analyses in order to elucidate wetland development, regional vegetational change and the context of individual sites and stray finds. The bulk of the Project's work consisted of archaeological and environmental survey, carried out by two or more full-time researchers in and around the wetland area. The majority of excavations were of prehistoric wooden trackways dating from the Early Neolithic to the Later Bronze Age, with the best known being the Sweet Track (Coles and Coles 1986). This Early Neolithic structure was discovered in 1970 and excavated at intervals where threatened by peat-cutting, until in the early 1980s efforts to protect the remaining lengths of the track came to fruition with the acquisition of the Shapwick Heath National Nature Reserve where 500 m of the Sweet Track lay below a surface wetland ecosystem of national significance (Coles 1995).

The well-preserved wood and surrounding peat of the Sweet Track, and the undisturbed and unweathered condition of associated cultural debris of both organic and inorganic materials, encouraged the use of varied methods of investigation, to see what results might be yielded (Figure 7.5). These ranged from analysis of microbial activity and fungal decay of the structural wood, to see how long it had been exposed before being engulfed by the peat, to microscopic examination of flints to determine their use (Carruthers 1979; Morris 1984). In the mid-1970s, when European dendrochronological sequences were being built up for the calibration of radiocarbon dates, it was hoped that the Sweet Track oak wood would provide material for an English calibration curve. This it did eventually, but not for some while (Hillam *et al.* 1990). In the meantime Morgan expanded her research from the establishment of internal site chronologies to a multi-faceted tree-ring analysis, which helped to elucidate when and how Neolithic and Bronze Age peoples had exploited and managed the woodlands in and around the Somerset Levels (Morgan 1988).

From 1975 to 1989 the *Somerset Levels Papers* were published, their appearance symptomatic of wetland archaeology in Europe, where the volume of data and the diversity of disciplines to be presented has meant that traditional publication outlets have proved inappropriate and projects have established their own series. Other examples are provided by *Archéologie neuchâteloise*, begun in 1986, and *Irish Archaeological Wetland Unit Transactions*, begun in 1993.

The various stages of the Fenland Survey in eastern England, funded by English Heritage from the mid-1970s onwards, included much walking of the arable fields of the former wetlands to identify ancient occupation from spreads of pottery and lithics, and building on Godwin's environmental work with transects of cores and use of radiocarbon dating to establish local sequences of wetland development. Use was also made of aerial photography to reveal both former wetland features such as the creeks of a salt marsh and signs of human

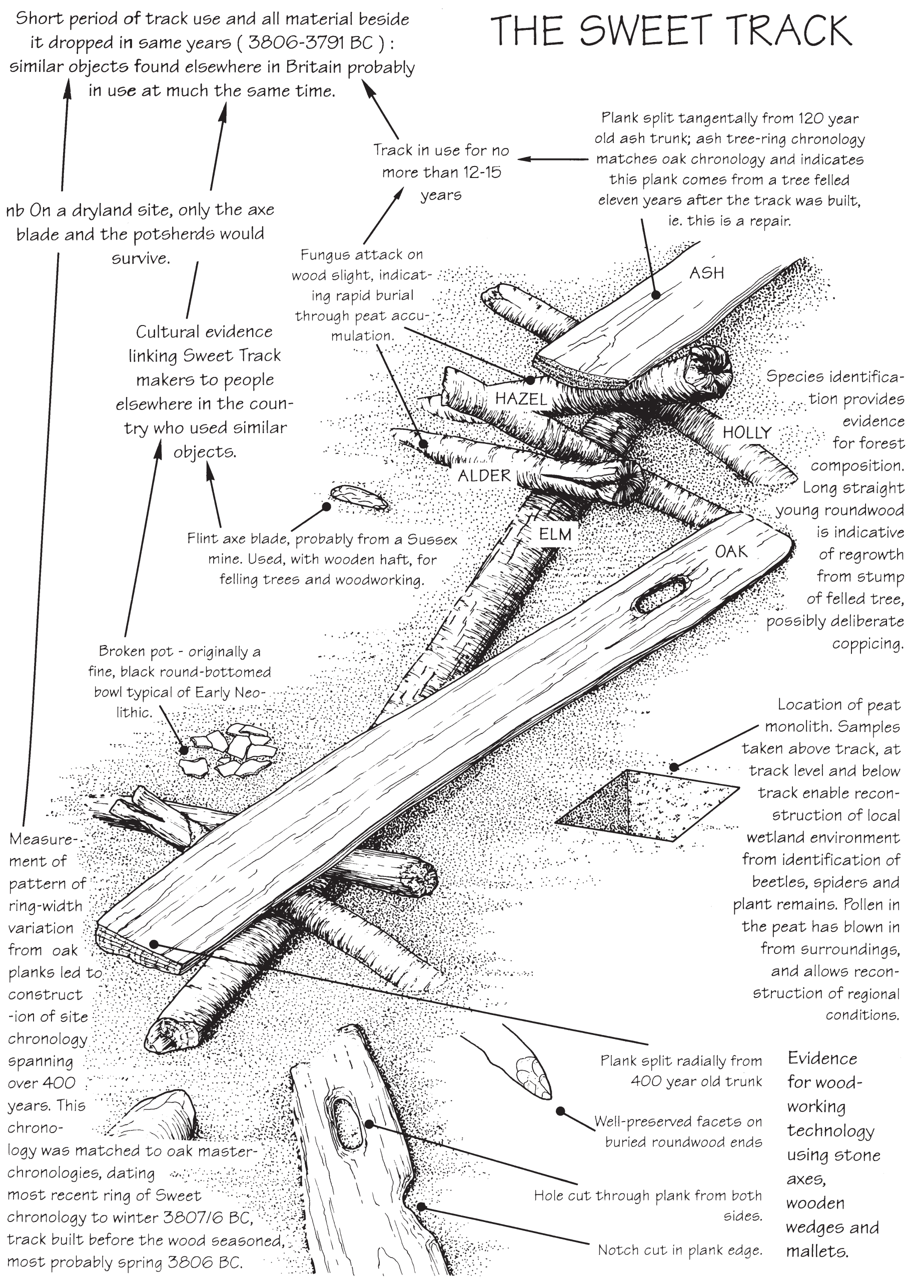

Figure 7.5 A diagram prepared to illustrate the range of scientific analyses applied to the Early Neolithic Sweet Track, from the 1970s to the 1990s (Coles 1995: Figure 1).

activity such as the in-filled pits of early peat digging. The Fens are a drowned landscape, overcome by wetland conditions only from the Neolithic onwards, and occasionally an earthwork which had once stood on the former land surface became engulfed by peat, to be revealed many centuries later when drainage and ploughing caused the peat to shrink and waste away. A number of sites were excavated, some on a large scale and others just enough to determine their state of preservation but, as in the Somerset Levels if not more so, the archaeological and environmental field survey were essential elements of the wetland investigations (Hall and Coles 1994). The work of Pryor, French and Taylor in the Flag Fen Basin (Pryor 2001) complemented the broader Fenland Survey and provided, with the Flag Fen Visitor Centre, a means of showing the visitor something of the otherwise invisible, vanishing wetland heritage of the region.

More recently, English Heritage has funded two wetland surveys in northern England, the North West Wetland Survey and the Humber Wetlands Project, both with the same strong emphasis on combining archaeological and palaeoenvironmental approaches (e.g. Middleton *et al.* 1995; Van de Noort and Ellis 1997). One outcome of the four surveys has been the realization of the diversity of England's wetlands and its effect on the character of human activity in the past and the subsequent preservation and discovery of evidence. The surveys have demonstrated that wetlands were an integral part of former landscapes, and they have provided the data for the development of strategies for long-term protection and management of the wetland heritage (Van de Noort 2002). Other English wetlands where significant research has taken place in recent years include Romney Marsh on the south coast (Long *et al.* 2002) and the Kent and Essex shores of the Thames Estuary (Wilkinson and Murphy 1995).

In Wales in recent decades, wetland archaeological investigations have been concentrated along the southern coastal belt, and one might well assume that this was in reaction to the industrial and commercial development which has taken place in the area. In part this is true, but a great deal of the work has been in response to coastal erosion which has exposed the deposits of former salt marsh and freshwater wetlands and revealed a diversity of evidence for human activity in the region bordering the Severn Estuary (Bell *et al.* 2000). Inland, commercial and transport developments have revealed occasional glimpses of the same wetlands, well buried by later deposits which themselves may have an historic surface landscape created by the long slow process of land reclamation and protection from the sea (Rippon 1996). Through the Severn Estuary Levels Research Committee, work on the Welsh and the English sides of the estuary has been brought together, across the national divide of the two main funding bodies CADW and English Heritage, and made public via *Archaeology in the Severn Estuary*.

In Scotland, perhaps because of the different character of wetlands in the past allied to differences in modern exploitation and development, there has as yet been relatively little systematic wetland research, and activity has been only sporadic in the later twentieth century. One landmark has been a survey of crannogs carried out for Historic Scotland by Barber and Crone (1993), with results that indicated considerable deterioration in condition since Munro and his contemporaries were at work, and further crannog research has been undertaken by Dixon, Hale and Henderson (e.g. Henderson 1998) Another project has focused on early lake settlement in the Hebrides, while the National Museum of Scotland has undertaken a programme of dating organic artefacts from its collections, with results that show many of the objects to be considerably older than expected (Sheridan 1996).

Bog bodies

There are some wetland finds whose treatment closely reflects the attitudes of society at the time of discovery rather than the cutting edge of wetland research, and bog bodies are perhaps foremost amongst these. A number of the bodies found during the centuries of hand peat-cutting were soon re-buried, and this happened well into the nineteenth century. On Whixall Moss on the border between England and Wales three bog bodies were found in the later nineteenth century, a young man in 1868, an adult woman in 1876 and an adult man in 1889. All were re-buried in Whixall Churchyard, without further examination (Turner 1995).

In 1958, the head of a man was found in Worsley Moss near Manchester. It did not arouse a great deal of interest and was not thought to be more than a few decades or a century or so old, although it was subjected to radiological and chemical testing. In 1987, following the discovery some 20 km away of the Lindow bog body which did arouse considerable public interest and sparked an array of scientific investigations (Turner and Scaife 1995), the Worsley head was given physical, radiological and dental examinations, energy dispersive electron analysis, histological analysis and AMS dating (Garland 1995). The date obtained showed that the Worsley person had probably been alive in the second century AD, during the Romano-British period, but as an old find as well as an ancient person, he never received the level of publicity granted to Lindow. The difference in interest can partly be explained by the growth of television archaeology between the 1950s and 1980s and also by the popularity in Britain of Glob's *The Bog People* (1969). It was also Glob who, to a great extent, inspired the scientific investigation of the British finds, through his account of the examination of the Tollund and Grauballe bodies.

Urban wetlands

This review of wetland archaeology in Britain has been concerned mainly with rural wetlands, but urban contexts are relevant too. It is well known that a number of historic European cities lie close to sea-level at the mouth of major rivers, and London is one of these. The Thames marshes have only gradually given way to the spread of the city over the centuries, and both in the nineteenth century and in recent decades there have been important archaeological discoveries and the development of multi-disciplinary research projects. The nineteenth century saw the creation of huge docks for shipping and reservoirs to provide water to the urban population, in the valley of the Thames and its tributaries notably the Lea. These were almost on the doorstep of the learned societies of London, easily accessible via the new railway, and the exposures became important for the early study of geology, river dynamics and sea-level change, and for the recognition of the fauna and artefacts typical of different recurring strata, all of which contributed to the emerging study of prehistory. In recent decades, development has revealed waterlogged Roman and Medieval waterfronts and evidence for associated structures and activities the excavation and analysis of which has made a great contribution to the history of London. Projects such as the new Jubilee Line underground railway have provided a transect along the Thames valley, allowing detailed study of the changing course of the river and character of the valley, including the nature and extent of human activity. From time to time, scattered smaller developments have revealed deposits of a particular period, allowing, for example, study of Bronze Age marshes and wooden trackways. It is likely that the antiquity of many of the ancient wooden remains revealed in earlier years was not recognized, and recent survey of the Thames foreshore has gathered material from old records as well as from current erosion. The above and other work in London's wetlands has been well integrated into the wider context, as is evident from *The Archaeology of Greater London* (Kendall 2000).

The other city in England which is renowned for its waterlogged archaeology is York, where early medieval levels were found to be particularly well preserved. In many respects, the York Archaeological Trust pioneered urban wetland excavation in Britain, giving due weight to all the different categories of structural, artefactual, economic and environmental evidence, and publishing the results of their investigation in their own series *The Archaeology of York.* The York Archaeological Trust also paid heed to the interests of visitors and undertook the ambitious Jorvik Museum to display and interpret the Viking city, smells and all.

Conclusion

At the start of the twenty-first century the *Journal of Wetland Archaeology* first appeared. It represents a further development of the subject and has grown out of *NewsWARP*, the newsletter of the international Wetland Archaeology Research Project (WARP) which was established by John Coles and the author in the mid-1980s. WARP is an informal network of archaeologists and others active in wetland research, and it provides a forum for discussion and dissemination of ideas and information. With members from Japan to North America to New Zealand, including most European countries, WARP demonstrates that the international character of wetland archaeology is as strong now as it was when Keller and Munro were active, recognizably regional in wetland diversity, national in the approaches to the organization of work, international in its sharing of scholarship and results.

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Part 2

LAKES AS LABORATORIES

The application of science

8

DENDROCHRONOLOGY IN LAKE-DWELLING RESEARCH

André Billamboz

Introduction

With its high-resolution dating potential, dendrochronology has proved to be a key method for the investigation of archaeological wood remains. This is particularly the case within the field of pile dwelling research, where the preservation of abundant waterlogged timber offers suitable opportunities for the large-scale application of the tree-ring dating process. Along with methodological improvements in wetland archaeology and the possibilities provided by computing techniques, dendrochronology applied to this field of research and based on dendroarchaeological methods (Kaenel and Schweingruber 1995) has developed exponentially during recent decades. In the north Alpine range, the occupation of Neolithic and Bronze Age bog and lake-shore settlements can now be followed on a calendrical time scale, a level of precision which the archaeologists dealing with the shifts of contemporaneous dynasties in the ancient world can only envy.

The aim of this chapter is to review the considerable success to date in establishing the dendrochronological framework and further, to discuss the future prospects at the beginning of the third millennium. The history of the subject since the discovery of the first pile dwellings in Zürich-Meilen 150 years ago can be outlined in the following steps.

Wood archaeology and tree-ring research in the forefront of European dendrochronology

During the second half of the nineteenth century, archaeological investigations and excavations allowed a first insight into the architecture of pile dwellings, emphasizing the role of timber in their construction. The coloured plans of wooden floors from Aichbühl in the southern part of the Federsee can be considered as the first records of these house structures in bog settlements (reproduced in Schlichtherle and Wahlster 1986). The series *Pfahlbauberichte* edited by F. Keller, Zurich, reported observations which were directed to post fields or individual pieces of timber, evidence of tool marks, and further evidence for architectural reconstructions. However, most of these considerations were directly related to the subsequent 'pile dwelling' discussion. In the same way, a tentative identification of the endogenous tree species used was made by observation of macroscopic criteria with the naked eye. In the 1920s, the excavation programme at the Federsee, under the leadership of R.R. Schmidt, underlined a significant step in the advance of wetland archaeology, first developing the recording of wooden floor structures by using vertical photography and, second, paving the way for the cooperation of natural sciences.

Within the field of wood biology, a parallel evolution can be outlined. The development of microscopy and the observation of wood anatomical and tree physiological features, focusing especially on the cambial formation of tree-rings (investigations by Th. and R. Hartig, cited by Schweingruber 1988) from 1850 onwards provided the preconditions for incubating dendrochronology. In the early decades of the twentieth century, E. Neuweiler (1925) was the first to perform anatomical identification of timbers from Swiss pile dwellings, giving quantitative evaluations of the endogenous species which were used in the constructions. During the same period dendrochronology itself was being developed, with A.E. Douglass starting his pioneering work in the American South-west just after 1900. He was looking at abrupt changes in annual growth in the tree-ring series of ancient ponderosa pines (*Pinus ponderosa*) in the vicinity of Flagstaff and Prescott, and was able to record as 'skeleton plots' the distribution of the so-called 'pointer years' over the last five centuries. He continued his investigations with the collaboration of archaeologists, who organized the sampling work in the form of 'beams expeditions' during the 1920s. Bridging both modern and archaeological chronologies, he finally established a calendar scale for the precise dating of numerous prehistoric pueblos and rock shelters of the Anazasi culture on the Colorado Plateau (Douglass 1935). A year later, the foundation in Tucson of the first tree-ring laboratory has to be considered as a milestone in the career of Douglass and in the development of dendrochronology world-wide.

Pioneering dendrochronology in Europe

The history of European dendrochronology can be traced through the writing of D. Eckstein and S. Wrobel (1983) who give a general overview, and others who report regional developments, for example M. Gräslund (1984) in the Nordic countries, M.G.L. Baillie (1982) in the British Isles, and F. Serre-Bachet (1985) in the Western Mediterranean area. Dendrochronology reached Europe first in the Nordic countries around 1920, with isolated attempts at investigating tree-growth in relation to climate also made by Douglass himself (Gräslund 1984). During the course of the 1920s, research in this region was driven by the teleconnection approach initiated by G. de Geer, leader of the Geodendrochronological Institute in Stockholm. He was a pioneer in geological dating and believed in the common influence of world-wide cosmic factors acting in various ways, hence 'teleconnecting' with one another on the surface of the earth. As a result, he saw the possibility of cross-dating past natural and geoclimatical processes on a large scale. For example, he attempted to correlate the variations of American tree-rings series and those of laminated sequences of lake sediments in North Europe. Within this scope, his wife E.H. de Geer began to collect and analyse wood materials from diverse sites in Europe (among others Novgorod in Russia, Biskupin in Poland and Raknehaugen in Norway).

Meanwhile, in West Middle Europe, the same wave of interest reached the archaeological field in the person of H. Reinerth, who, during the successive excavation campaigns at Federsee in the 1920s, observed the advance of dendrochronology in America (Reinerth 1940). Following a similar model, he was expecting to find suitable samples of comparable long-lived softwood species. Meanwhile, having acceded to the head of German prehistory (Reichsbund für Deutsche Vorgeschichte) under the national socialist regime in 1934, he expressed his own scepticism about the teleconnection hypothesis, arguing that Middle European dendrochronology should first be supported by basic investigations of endogenous materials.

This sceptic position was already shared by B. Huber, tree physiologist at the Institute of Forestry Botany in Tharandt (Technical High School, Dresden). Huber's first exposure to the method was the paper of W. Glock (1937), who had discussed the methodological aspects and possibilities of dendrochronological cross-dating with reference to the work of Douglass. This led him to investigate the tree-ring series of different species, and along with his students W. Wittke and J. Zittwitz he explored the relationships between tree growth, regional climate and site conditions. Instead of using the American skeleton plot, recording only the years of abrupt changes of growth, he introduced the full tree-ring plot, putting each yearly variation of growth on the ordinate. Furthermore, the segments of reduced growth were enhanced in the curve through the use of a logarithmic scale for this axis.

As he reported later (Huber 1964), the possibilities of dendrochronology for dating purposes had been apparent to him from the beginning: 'When I heard of the method and its success, I perceived immediately its importance for applications in North and Middle Europe, given the numerous remains of wood-building and wood-working cultures represented there (prehistoric pile dwellings, medieval timber frames).' Thus, at a lecture at the Herrman-Göring Academie der Deutschen Forstwissenschaft on 6 September 1940, his concluding sentence was: 'Tree-ring dating is also possible in Middle Europe!' As a result of this pioneering work, Huber is now considered as the father of European dendrochronology (Liese 1978).

The fundamental research initiated by Huber in 1937 was very convenient for Reinerth and the two cooperated early on. After a first meeting during the summer, 1939, samples from the Neolithic site Hunte I at Dümmersee were submitted to the Institute in Tharandt for tree-ring analysis. Huber's assistant, W. Holdheide, specialized in wood anatomy, and was able to synchronize short tree-ring sequences of different softwood and deciduous tree species. This was, in fact, the first occasion in European dendroarchaeology when this inter-species similarity (heteroconnection) was studied.

In the following year, a contract was signed on 9 July 1940 between Reinerth's office and the laboratory of Tharandt, stipulating among others, the following main conditions: first, dendrochronological tree-ring plots should be reproduced for each partner. Second, the presentation of the dating results and their archaeological interpretation, as well as the establishment of a tree-ring chronology for the prehistoric period, was part of the archaeological responsibility, whilst the tree-ring information itself was made available to the working group in Tharandt for their evaluation in terms of climate change and woodland development.

In the same year, sampling began in several sites at Dümersee (Neolithic) and Federsee (Neolithic and Bronze Age). Following the American model, the softwoods formed the basis of these studies, using the bog-pine palisades of Wasserburg Buchau (Federsee). There was a dispute between Reinerth and O. Paret as to whether both palisade systems were constructed contemporaneously or resulted from a longer period of constructional activity, with repeated repairs. Concerning this question, Huber stated that for both palisades systems, the concentrated distribution of felling dates over only four years supported Reinerth's theory of contemporaneous construction without extensions or repairs. The lack of synchronization between the two respective tree-ring chronologies implied that both the phases of occupation were remote in time with a gap of at least 100 years (Huber and Holdheide 1942; for the absolute dating of the Wasserburg Buchau, see Figure 8.1). Thus, having obtained material from lake-shore sites at Bodensee (Figure 8.2) he cross-dated the pine chronology of the outer palisade and an oak chronology of Unteruhldingen. It was the first tentative synchronization between two sites dated to the Late Bronze Age and separated by a distance of around 80 km (Huber 1943). With the final outcome of the war, this work ceased and the tree-ring laboratory in Tharandt had to be closed.

Dendrochronology and radiocarbon compete for absolute dating

The post-war period is characterized by a general decline in pile dwelling research in Europe, particularly in South Germany. There, the only notable activity of wetland archaeology around 1950 concerns the rescue excavation of the bog site of Ehrenstein in the vicinity of Ulm, under the leadership of Paret. Huber moved to the University of Munich (Institute of Forestry Botany) after the war, and in 1952, began tree-ring investigations of non-oak tree species encountered there. Having cross-dated numerous alder series, he was able to infer that the succession of house floors took place within a short period of just eight years (Huber and von Jazewitsch 1958). However, the major aim of his work at that time was the construction of a master oak chronology for South Germany, starting from the historical period.

Opportunities for continuing Huber's interest in the field of pile dwelling research came from the Swiss Plateau, where excavation activity flourished

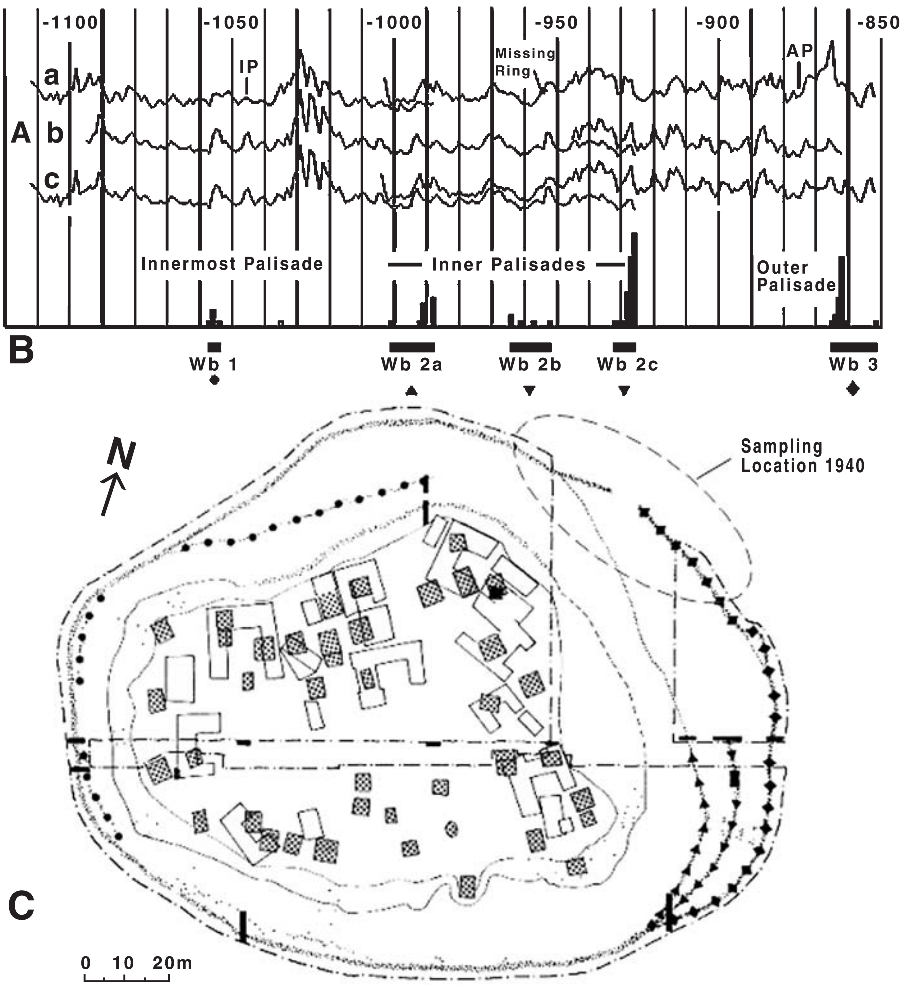

Figure 8.1 Bridging the times of dendrochronology at Wasserburg Buchau. A. Chronology building with bog pine from the palisade systems. Aa: Huber's chronologies IP and AP (latter with missing ring). Ab: chronologies of the tree-ring lab in Hemmenhofen based on new sampling from sondages drawn by the Landesdenkmalamt Baden-Württemberg and the Pfahlbaumuseum Unteruhldingen. An older chronology (1207–1054 BC) related to phase Wb 1 is not presented here. Ac: combined chronologies Aa and Ab on the absolute calendar scale. B. Phases of construction of the palisade systems as given by the distribution of cutting dates. C. Plan of the Wasserburg Buchau after H. Reinerth (1929, simplified) with palisades segments investigated (black rectangles: sondages 1980), showing the development of construction between 1058 and 852 BC.

Figure 8.2 Sampling activity at Bodensee during a fall in the water level in spring 1942 at the Neolithic site of Unteruhldingen-Bayenwiesen. Photograph: H. Reinerth, reprinted from Schöbel 1995, courtesy of G. Schöbel, Pfahlbaumuseum Unteruhldingen.

during the 1950s. In 1952, he contacted E. Vogt, who made the Egolzwil 3 material available. By grouping the ash series according to cambial age and growth trend, we can say that Huber was, in fact, the first to apply dendrotypology. By far the largest sample series was provided in 1953/4 by J. Speck's excavations in the Late Bronze Age site of Zug-Sumpf, which contained nearly 1,500 individual timbers. Relative cross-dating was successful between the longest tree-ring series of oak, ash and alder (Huber and Merz 1962).

In 1956, Huber visited the excavation at Thayngen-Weier, a bog site near Schaffhausen investigated by W.U. Guyan. A year later, a similar excavation programme was launched in the lake-shore sites of Seeberg, Burgäschisee under the leadership of G. Bandi and H.J. Müller-Beck. Beyond the pile dwelling discussion, research focused now on questions of site archaeology. The non-linear development of wetland occupation was seen by archaeologists in terms of settlement phasing in relation to cyclic rotations of shifting cultivation, whereas botanists were arguing that climatic fluctuations, which could have modulated the access to wetland, were responsible for the observed changes. Huber cross-dated the oak series from Burgäschisee-Süd and Südwest, and from Thayngen-Weier I and II and thus demonstrated, on a relative scale, that the occupations of these villages were more or less contemporaneous, with respective time shifts of less than 50 years (Huber 1967). Furthermore, the first samples from an excavation in the bog site of Niederwil, whose larger timber series were the focus of a thesis by A.V. Munaut, could be assigned to the end of the same occupation phase. These results, allowing a precise link between the Michelsberg and the Cortaillod Cultures, were hailed as a breakthrough by the archaeologists, but the dendrochronologists were a little disappointed as they were seeking a more staggered distribution of materials in time for the purposes of chronology building.

Several years previously, opportunities to improve the chronological framework beyond the limits of typological and cultural analogies arose from the radiocarbon method introduced by W. Libby, who was awarded the Nobel Prize in 1960 for his work. As an attempt at defining an absolute time scale for the floating tree-ring chronologies, the first ^{14}C-measurements were achieved by the Bern laboratory, using wood samples from Burgäschisee-Süd. The resulting dates indicated that the occupation occurred at around 2600 BC. Thus, progress in this field of research highlighted the necessity to calibrate radiocarbon dating, since it was affected by some environmental effects (variations of the ^{14}C-level in the atmospheric carbon dioxide in the past and an increase in the radiocarbon content during modern times resulting from the combustion of fossil fuels). Beginning with a 3,000-year sequoia record, *Sequoia gigantea*, steps towards establishing a calibration curve were achieved after discovering the long-lived bristlecone pine, *Pinus longaeva*, in the White Mountains of Nevada, by E. Schulman, Douglass' assistant in Tucson. The construction of a long chronology spanning the whole Holocene allowed a systematic sampling of tree-ring segments for ^{14}C-measurements, leading to the nearer recognition of short-term wiggles in radiocarbon content, as well as a long-term deviation from the calendar scale given by the tree-ring chronology. On this basis, a first attempt at matching the tree-ring chronologies of Burgäschisee-Süd and Thayngen-Weier on the calibrated time scale was made (Ferguson *et al*. 1966), and this shifted the occupation dates 1,000 years earlier.

This new dating was not at first accepted by the whole archaeological community, who had to admit that the Neolithic pile dwellings had been erected much earlier than the pyramids in Egypt. During the following years, the calibration curve was optimized using high-precision measurements and by reducing the oversized wiggles. A second pile dwelling application was the calibrated dating of oak pile series from the site of Auvernier-Saunerie on the shore of Lake Neuchâtel.

Flourishing dendrochronology from the 1970s onwards

This period belongs to the second and third generations of dendrochronologists in Europe and is characterized by a renewal of interest in archaeological wood remains, both from the point of view of anatomical and techno-morphological aspects, as well as the problems of wood conservation. Coupled with this, the spread of computing techniques and the birth of the personal computer paved the way for a prompt development of applied dendrochronology. First, U. Ruoff installed a tree-ring laboratory as sub-unit of the Archaeological Service of the City of Zurich, which linked dendrochronology with diving activities and rescue excavations in the local lake-shore sites. The process was accelerated by the main road programme in the Jura-Lake region, within the framework of which large portions of the shore had to be excavated, providing a huge amount of wood samples. During the first excavations in the Auvernier Bay, a tree-ring laboratory was set up in 1973 in Neuchâtel under the advice of F.H. Schweingruber in Birmensdorf.

In subsequent years, this model was reproduced with the creation of further laboratories in West Switzerland (Moudon, Bern now Vinelz) and in other countries of the northern Alpine range (Besançon and St Bonnet de Chavagne in France, Hemmenhofen, Munich now Thierhaupten in Germany, and Vienna in Austria). South of the Alps, following the initial investigations in North Italy at Fimon by A. Rufo in 1972, the Istituto italiano di dendrocronologia was created in Verona in 1983. Its first task was to investigate several Early Bronze Age sites around Lake Garda. Later, a further unit was installed in Slovenia, with special focus upon the prehistoric sites of the Ljubljana moor.

Simultaneously, the development of fundamental research allowed the final establishment of a dating reference. After B. Huber retired (Figure 8.3), the tree-ring laboratory of Munich was relocated to the University of Stuttgart-Hohenheim in 1970. Its new leader, B. Becker, confronted with the question of the postglacial development of landscape, and following the pioneering work of his mentor on the construction of a long oak chronology, began the systematic sampling of sub-fossil trunks in the alluvial deposits of the Danube, Main and Rhine. With the support of radiocarbon dating and following comparison with other long oak chronologies from Ireland and North Germany, the last remaining problems related to uncertain cross-dating or insufficient sample replication could be solved and finally, a 10,000-year long chronology for South Germany and the neighbour regions was presented which spanned both the Neolithic and Bronze Age on the same absolute time scale (Pilcher *et al.* 1984). Subsequently, under the leadership of B. Becker, a small group of laboratories dealing with investigations in the lake-dwellings north of the Alps assigned the new calendar scale to the respective regional or even local sequences, which until then had been considered as 'floating' (Becker *et al.* 1985). At the same time, this group created a network, which eventually developed exponentially to embrace the whole community of European dendrochronologists under the name Eurodendro. This common publication, recording all the dendrodates of the north alpine pile dwellings on the same absolute scale, can be considered as a milestone in pile dwelling research, providing the archaeologists with a precise chronological framework for typological studies of artefacts, technological and architectural development, and even site and landscape archaeology.

The same evolution can be identified in other centres of wetland archaeology. First, on the basis of the Irish and north-west German chronologies, numerous trackways crossing bogs in North Ireland and Low Saxony could be dated,

Figure 8.3 Two generations of dendrochronologists. B. Huber (sitting), as he retired in 1969 and the team of the Institute of Forestry Botany in Munich, with B. Becker (fourth from the left) and V. Siebenlist-Kerner (second from the right). Photograph: courtesy of V. Siebenlist-Kerner.

mainly to the Bronze Age. Together with Alvastra in Sweden, tree-ring investigations in wetland sites outside the Circum Alpine domain were undertaken in the English fens, Scottish crannogs and in Poland at Biskupin. Furthermore, with the creation of new laboratories, the expansion of the dendrochronological network led progressively to the dating of wood constructions related to various human activities in wetlands or at cutting sites (bridges and river coast constructions, fishing piers, harbour constructions and landing places). Directly linked to this topic, dendrochronological investigations of wooden water craft were still developing. Numerous case studies report on the dating of log boats or composite flat boats found in bogs, coastal regions or river beds. Dendrochronological dating applied to shipwrecks particularly flourished in North West Europe and more recently in the Mediterranean region.

Turning again to pile dwelling research, attempts at bridging the domains north and south of the Alps dendrochronologically has still not been achieved. An alternative to absolute calendrical scale of dendrochronology was found using the radiocarbon method with extended wiggle matching. An early application concerned a set of oak chronologies from different sites at Lake Garda (Fasani and Martinelli 1996), which allowed the development of the Early and Middle Bronze Age lake-shore occupation to be determined with a precision of ±11 years. This approach was replicated with local oak sequences from different Italian alpine piedmont sites, and with a larger larch chronology from Fiavé. Recently, the same method was used for dating the first oak and ash sequences from Neolithic sites of the Ljubljania bog complex (Ljubljansko barje) in Slovenia (Cufar *et al*. 1997).

A major aspect of dendrochronological development within pile dwelling research from the 1970s onwards was the systematic character of its application. Beyond simple dating exercises, the availability of large sample collections as, for example, those resulting from the rescue excavations in Switzerland, allowed the question of the structural organization of the villages to be addressed through the provision of well-replicated cutting dates. As an example, the largest series are to be found in Zürich-Mozartstrasse with around 30,600 pieces of timber collected (6,400 investigated samples), Hauterive-Champréveyres with 8,200 (7,700), Concise-sous-Colachoz with 9,000 (5,500), and Hornstaad-Hörnle I with 20,000 (4,800). These tree-ring studies included numerous young wood samples with few rings, and pushed the dendrochronological application beyond the established limits, representing a new challenge (Orcel 1980). Also, as a result of identifying cross-dated pile series, house structures could be determined, allowing the reconstruction of the internal building development and organization, a process initiated by B. Huber for the Late Bronze Age villages of Zug-Sumpf. However, this approach implied that timber was not reused over time and was mainly restricted to use within a single familial unit. Furthermore, the contemporaneity of several villages as demonstrated in the Auvernier Bay area during the twenty-eighth century BC led to more precise speculations about demographic development of lake-shore settlement. Nowadays, this approach is particularly applied by P. Pétrequin for the Late Neolithic occupation at Lac Chalain. In the same manner, the occurrence of cutting dates was evaluated in two further ways. First, based on the Neolithic series of Twann, which showed a development of human activity in nearly decadal steps, the question of settlement relocation modulated by cycles of shifting cultivation was revived in archaeological discussion. Second, the influence of climate on the development of wetland settlement could be more closely addressed. Major phases of occupation were apparently linked with warming periods, as indicated by decreasing radiocarbon production in relation to higher solar activity (Magny 1993; Gross-Klee and Maise 1997).

Another aspect concerns the evaluation of the large wood series in terms of woodland use, enhancing the strong relationship between timber sources, architectural adaptations and woodland development in the settlement surroundings. Here, the first observations have concentrated on the alternation or combination of the species used in constructions. This is particularly the case in northern Switzerland and in southern Germany, areas with a large distribution of beech forests, where oak was only moderately represented. In contrast, in western Switzerland, a more general use of oak timber can be demonstrated.

With regard to woodland management, the dendrotypological method was set up in an attempt to sort the tree-ring series, and the related timber, by means of dendrological (species), dendrochronological (cambial age, growth rate) and techno-morphological (degree and type of stem conversion) parameters. In this way, different models of woodland management could be highlighted, following the development of human occupation from the first clearing to the final thinning through phases of secondary coppice formations (Billamboz 1987). This approach continued the pioneering work of Bruno Huber and his first evaluation of the bog-pine stem material from the Wasserburg Buchau. For large oak series, subsequent investigations were drawn from a similar perspective by the tree-ring labs in Neuchâtel (Hauterive-Champréyres) and Moudon (Yverdon-Avenue des Sports, Concise-sous-Colachoz). Further stimuli for this research came also from England with Oliver Rackham's work, relating historical ecology to practices such as coppicing (Rackham 1980).

Throughout this period, the development of fundamental tree-ring research was characterized by the development of 'dendroecology' led by Schweingruber, who, since 1970, had been pressing for the maximal evaluation of tree-ring characteristics for a better understanding of tree growth, not only in relation to climate, but much more in the local context of site and stand conditions (Schweingruber 1988, 2001). Through numerous field and lab weeks, he imparted his enthusiasm and vision of tree-ring research to colleagues and students from different fields of science, bringing them together under the common topic of tree growth as recorded in its tree rings. Subsequently, dendroarchaeology moved in a similar direction and new possibilities for the evaluation of archaeological tree-ring data opened up.

The third millennium: a new challenge for dendrochronology applied to wetland archaeology

Looking at the present state of, and future prospects for, wetland dendroarchaeology, it is possible to draw some conclusions. The differences in dating ability north and south of the Alps means that the focus of research in these two areas is, necessarily, still divergent. To the south, as result of indications due to a later start of research, a lack of wood preservation, and a larger discontinuity of wetland occupation, chronology building will remain the major aim for some time. To the north, well-replicated regional chronologies exist for oak, but this chronological network may still be developed through cross-dating different species (heteroconnection). This is especially likely in the eastern part of the alpine foreland and could lead to the dating of structures or phases of occupation where oak was not used. Thus, beyond the chronological needs, other factors can nowadays also become a focus of research in this area.

The relationships between climate evolution, environmental change and human settlement patterns can now be addressed using the long tree-ring chronologies spanning the whole period of lake-dwelling occupation. Along with the South German oak chronology, derived from the sub-fossil trunks found in deposits of the rivers Danube, Main and Rhine, a softwood (pine and larch) chronology is in an advanced stage of construction in the eastern Alps (Nicolussi and Patzelt 2000). By looking at synchronous short- and middle-term variations of growth along these chronologies, common climatic signals should be highlighted.

Investigations of the Bronze Age in south-western Germany (Billamboz 2003) have already proved that the archaeological tree-ring data must be involved in this process. In particular, the cross-dating of different tree species from varying ecosystems (zonal and azonal vegetation) has been shown to be a suitable method for sorting related factors acting at different scales, and, indeed, this also offers consistent information for comparison with other high-resolution proxies. Furthermore, special attention should be paid to wetland tree species, which can provide us with precise information about the short-term changes of hydrological conditions and the consequences for human settlement (Figure 8.4).

With their unequal distribution in space and time, dendroarchaeological tree-ring data reflect the development of human occupation. Compared with continuous series from natural deposits, which depend mainly on wood sampled

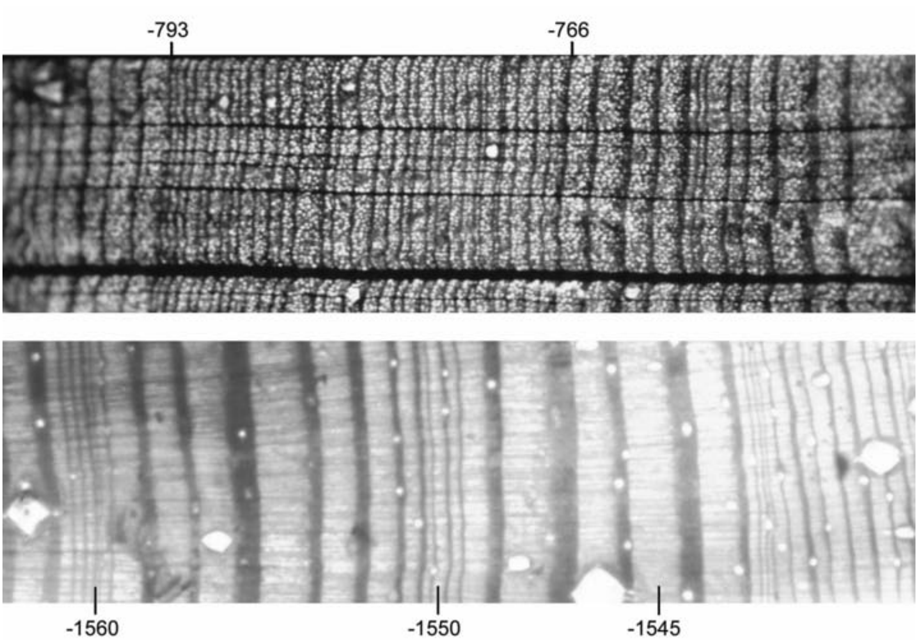

Figure 8.4 Tree-ring content from a palaeoecological perspective. Top: long-term depletion of growth between 793 and 766 BC. in a beech series (log of a fishing weir in Oggelshausen-Bruckgraben at Federsee) enhancing the negative change of climate at the beginning of Iron Age. Bottom: bog pine series from the palisade at Siedlung Forschner (Federsee) showing several short-term depletions of growth between 1563 and 1540 BC, which are characterized by a very low formation of late wood probably due to an an excessive amount of water. At that time, there is no evidence for settlement between either of the last phases of occupation dated to around 1600 and 1500 BC, respectively.

from rather old trees (Spurk *et al*. 2002), the more widely distributed timber series from bog and lake-shore sites provide a unique collection of converted stems from harvested trees which grew under similar ecological conditions in the settlement surroundings. With the high variability of cambial age, these trees provide additional information about structure and stand dynamics, modes of exploitation and, through discontinuities and changes in sample depth of the dated series, about woodland development in this vegetation belt.

As outlined above, dendroarchaeology, supported by dendroecology, can give great palaeoecological insight. For example, looking more closely at anatomical features may allow specific questions related to environmental change (e.g. the effects of flooding, frost or insect defoliation) or human activity (seasonal cutting, pollarding, shredding or coppicing) to be addressed. In a similar way, advances in the field of dendrochemistry, allowing a closer insight into the processes of wood formation, already provide further information about the relationships between tree-growth, climate change and site conditions. This allows, on one hand, the enlargement of the climatologic network by adding proxies from isotope measurements and, on the other hand, more specific topics like the provenance of timber to be dealt with.

Indeed, there is a great opportunity now for dendroarchaeology to provide precise references about human–environment relations in the past and thus increase its contribution to issues of current interest in ecology and environmental research. In particular, within the field of pile dwelling research, where tree-ring investigations are still principally used for dating and resolving archaeological questions, more balance between fundamental and applied research is needed. At the same time, these considerations should be a warning to those archaeologists who still see dendrochronology only as dating technique. Certainly, considering the financial aspects of investigation, the ball is mostly with field archaeology. By focusing only on the primary information and short-term evaluation, archaeologists should be aware of the risk of scoring an own goal!

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9

THE CONTRIBUTION OF PALAEOCLIMATOLOGY TO THE LAKE-DWELLINGS

Michel Magny

Introduction

Palaeoclimatology and lake-shore archaeology: a long and confused relationship

From their discovery in the middle of the nineteenth century to the 1970s, the remains of Neolithic and Bronze Age villages found along the shore of sub-Alpine and Jurassic lakes caused angry controversies in the archaeologist community. Indeed, how could one explain the presence of settlement remains below the present water-level? The Swiss archaeologist F. Keller interpreted them as true lake-dwellings (*Pfahlbauten*), like tropical lacustrine or sea-shore villages reported at that time by famous navigators. In this interpretation, it is assumed that the lake-level (and consequently the climate) has not changed since the Neolithic period (Figure 9.1, top).

As early as 1922, the German H. Reinerth proposed a different picture. From his point of view, the prehistoric lake-shore dwellings were built directly on the ground, or they had a slightly raised floor as a preventive measure against seasonal floods, when the lake-level was lower than today due to a drier climate. H. Reinerth's scenario was based on careful archaeological excavations and observations of architectural structures on Lake Feder and Lake Constance in Germany. It was also supported by the first climatic outlines established for the Holocene period in 1908 by the Scandinavian palynologists A. Blytt and R. Sernander (Birks and Birks 1980), and in 1923 by the palynologist H. Gams and the geologist R. Nordhagen in Central Europe. Furthermore, in a magisterial palynological study of the Gross Moos region between Lakes Neuchâtel, Morat and Bienne in Switzerland, W. Lüdi showed in 1935 that mid-European lake-levels underwent multiple variations during the whole Holocene period and, more particularly, marked lowering phases during the Neolithic and Bronze Age periods.

From 1942 to 1955 a group of Swiss and German archaeologists led by O. Paret and E. Vogt went even further by affirming that prehistoric lake-dwellings never

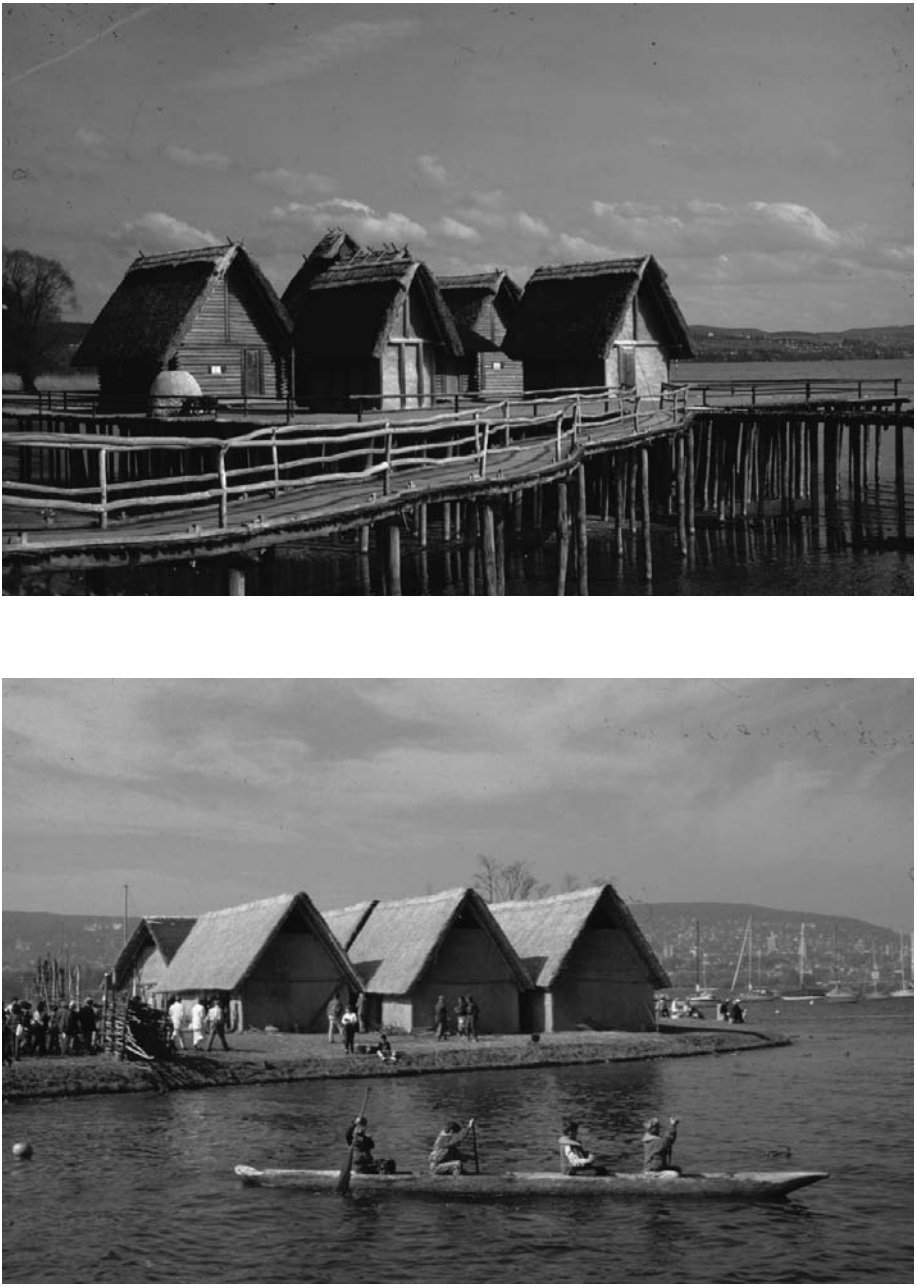

Figure 9.1 Top: an example of F. Keller's interpretation, a reconstruction of a prehistoric lake-dwelling at Unteruhldingen (Bodensee, Germany) in the 1930s. Bottom: an example of O. Paret's theory: a reconstruction of a prehistoric lake-shore village presented in Zurich (Switzerland) in 1990. Photographs: M. Magny.

existed and relegating them to myths (Paret 1948). According to them, only one scheme appeared reasonable: prehistoric villages were built on the ground during phases of lake-level lowering induced by a drier Sub-Boreal climate (Figure 9.1, bottom).

Finally, the development of new archaeological excavations at sub-Alpine and Jurassic lakes since 1970, the use of more rigorous techniques by the archaeologists and some exceptional findings such as the Bronze Age settlements of Fiavé-Carera in northern Italy have progressively shown that various types of lake-shore dwellings existed during the Neolithic and Bronze Age periods in central Europe: houses built on the ground, houses with slightly raised floors, or houses on piles (true lake-dwellings). At Lake Clairvaux (French Jura), P. Pétrequin has even suggested that all types may have coexisted in the same village!

Thus, if the old controversy about prehistoric lake-dwellings were solved by the acceptance of a third way, the possible correlations between the periods of extensive lake-shore settlements and Holocene climatic oscillations would appear less clear than in Reinerth's or Paret's theory. However, radiocarbon and tree-ring data collected since 1970 have progressively given evidence for periods of general interruption of prehistoric lake-shore settlements, for instance between 1500 and 1150 BC or after *c*. 800 BC, attributed to the possible impact of climate changes.

While the controversy between archaeologists about prehistoric lake-dwellings was appeased, palaeoclimatic investigations were marked by a large development in Europe. The reconstruction of past changes in lake-level, initiated in Sweden by T. Nilsson in the 1930s, then by G. Digerfeldt from the 1960s, and as early as 1935 by W. Lüdi in Switzerland, was in particular favoured by the Unesco Program IGCP 158, 'Palaeohydrological changes in the temperate zone in the last 15,000 years', under the leadership of the Swede B. Berglund. This general scientific context was favourable to the establishment of a more precise climatic history of the Holocene period (Berglund *et al*. 1996), offered greater opportunities for exchanges between archaeologists and palaeoclimatologists and contributed to a better understanding of the past environmental conditions underlying the development of Neolithic and Bronze Age lake-shore villages. In fact, if lake basins are among the privileged areas for palaeoclimatic investigations in continental areas, lake-shore archaeological sites offer additional advantages in terms of high-resolution sediment sequences for reconstructing past environmental changes and Holocene climatic variability thanks to both high sedimentation rates and high-precision tree-ring dates.

Reconstructing past lake-level fluctuations

The reconstruction of past lake-level fluctuations from the study of sediments accumulated in lacustrine basins necessitates recognition of the water depth of past deposition environments and, thus, definition of bathymetric markers. The reconstruction of past environmental conditions is most often based on the observation of present environments and the analogy principle: the laws determining the working of present geo- and ecosystems are assumed to have been the same in the past.

Two methods have been used to reconstruct past changes in lake level in the sub-Alpine area. The first, established by G. Digerfeldt (1988), is used by botanists. It is based on changes in the distribution of lake vegetation. Macrophytic vegetation is largely determined by water depth resulting in a characteristic zonation of emergent, floating-leaved and submerged vegetation from the shore to the deep water. Hence, changes in vegetal macrofossil assemblages in a sediment core can be assumed to reflect variations in the water depth at the core site. This type of approach, like the following one, most often includes the study of several cores along transects perpendicular to the shore.

The second method was developed by sedimentologists (Brochier and Joos 1982; Moulin 1991; Magny 1992). It is based on a combination of multiple parameters, including changes in sediment texture (coarser deposits correspond to near-shore areas), lithology (organic deposits often characterize shallow water), and assemblages of various carbonate concretion morphotypes. These concretions dominate the coarser fractions of lake marl in most Jurassic and sub-Alpine lakes. Modern analogue studies have revealed that the different concretion morphotypes (globally associated with aquatic vegetation belts) show a characteristic zonation from the shore to the deep water. Thus, in the same way as in the botanic approach, changes in the relative frequency of each of these morphotypes can provide indications of past lake-level fluctuations.

Other markers can also be used to reconstruct past variations in water-levels, for instance diatom, chironomid or oxygen-isotope analysis (Berglund 1986). Whatever the approach may be, the basic principle is to ground the reconstruction of past lake-level conditions on specific naturalist markers, independent of anthropogenic artefacts or structures, too often linked to uncertain, questionable interpretations as exemplified by the long-lasting lake-dwelling controversy.

Establishing a regional pattern of lake-level changes

Lake-level changes can be caused by climatic parameters affecting both evaporation and precipitation, but also by non-climatic local factors including geomorphological or hydrographic phenomena. Only synchronous changes in several lakes within a region can testify to their climatic origin. Thus, the strategy adopted to test possible correlations between variations in climate and the history of Neolithic and Bronze Age lake-shore villages has been to reconstruct Holocene water-level fluctuations in a large number of lakes. Figure 9.2 shows results obtained over the last 20 years from 29 lakes in a mid-European region composed of the Jura Mountains, the northern French Pre-Alps and the Swiss Plateau (Magny 2004). These data indicate that the whole Holocene period was punctuated by alternate higher and lower lake-level phases. This points to a rather unstable Holocene climate, as also illustrated by variations in glacier-tongue length or tree-limit altitude in the Swiss and Austrian Alps (Zoller 1977; Patzelt 1985; Burga and Perret 1997; Haas *et al*. 1998). Besides, glaciologists

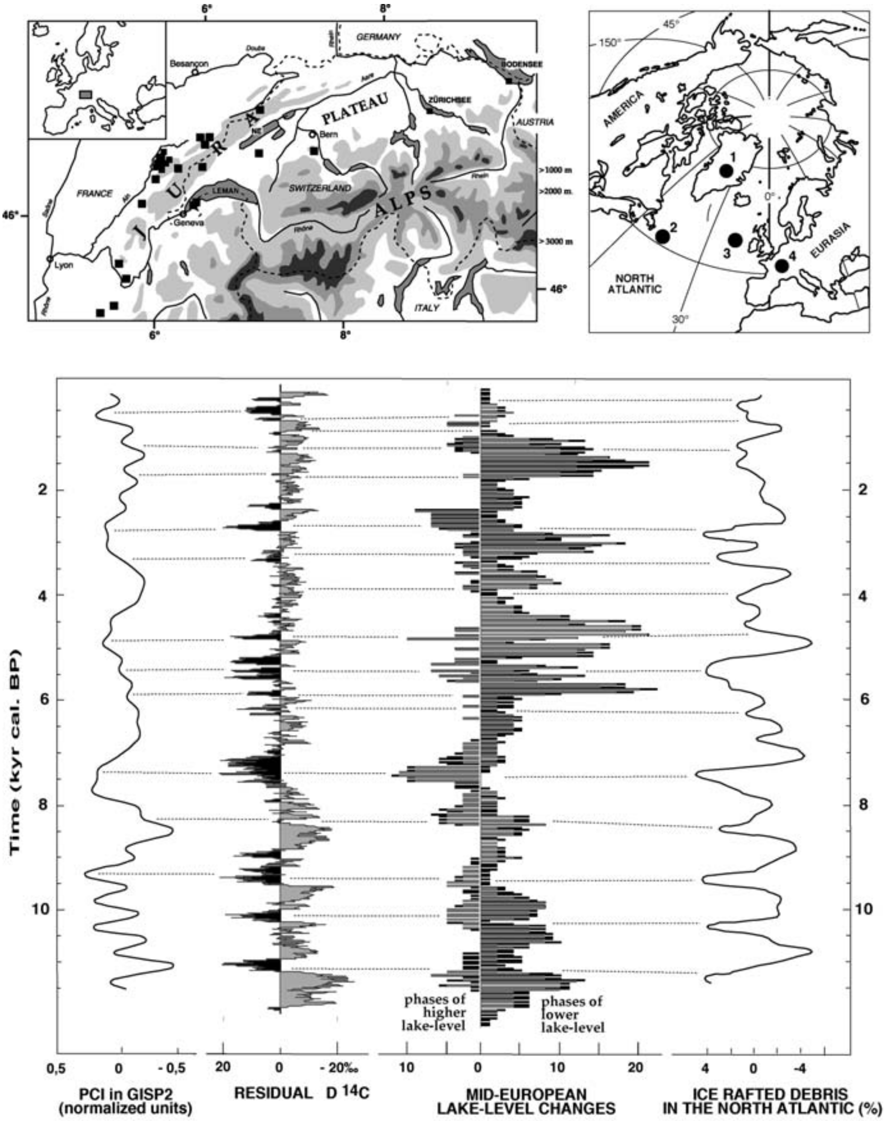

Figure 9.2 Top panel (right): geographical location of the records presented in the lower panel. 1. GISP2 in the Greenland ice sheet (Mayewski *et al*. 1997), 2 and 3: cores MC21–GGC22–JPC37 and VM29/191–VM23/81–MC52 in the North Atlantic Ocean (Bond *et al*. 2001), and 4: mid-European lakes (Magny *et al*. 2004). Top (left): geographical location of the Holocene lake-level records used to establish the mid-European lake-level record presented in the lower panel (Magny 2003). Bottom panel: comparison between the Holocene record of the Polar Circulation Index (positive values of PCI mark colder climate) at GISP2 (Mayewski *et al*. 1997), the atmospheric residual ^{14}C variations

and palynologists have demonstrated as early as the 1970s that the 1500–1850 AD glacial advance well documented by historical data and known as the 'Little Ice Age' is only the most recent episode of successive climate cooling punctuating the entire Holocene. Moreover, a synchronicity has been observed between phases of higher lake-level in the Jura Mountains and on the Swiss Plateau, glacier advances and tree-limit declines in the Alps, and periods of higher river discharge in Poland. These inter-regional correlations suggest multi-centennial climate oscillations on a European scale marked by an alternation of cooler-wetter and warmer-drier phases (Magny 1993b, 1995).

In order to test its climatic significance and implications, this mid-European lake-level record is compared with three other palaeoenvironmental records (Figure 9.2). The Polar Circulation Index (PCI) established by Mayewski *et al.* (1997) from the GISP2 glaciochemical series is thought to provide a relative measure of the average size and intensity of polar atmospheric circulation (PCI values increased during colder portions of the GISP2 record). The ^{14}C curve presents the atmospheric ^{14}C residual series based on tree-ring records (Stuiver *et al.* 1998). This ^{14}C record may be considered as proxy for past changes in solar activity. Given that the variations in atmospheric ^{14}C present strong similarities

(Stuiver *et al.* 1998), the mid-European lake-level fluctuations (Magny 2003), and the ice-rafting debris (IRD) events in the North Atlantic Ocean (Bond *et al.* 2001). Note that the lake-level record presents two histograms based on the distribution of the radiocarbon and tree-ring dates of higher and lower lake-level events reconstructed in the Jura mountains, the northern French pre-Alps and the Swiss Plateau over the Holocene period. Both the histograms have been constructed as follows. Every time a 50-year period was documented in a one or two sigma calibration time-window, it was given with two or one points respectively, and three points if documented by a tree-ring date. The score peaks in both higher and lower lake-level histograms are not directly proportional to the magnitude of recorded events, but reflect the present state of the documentation and may also depend on the duration of the episodes. Moreover, the standard deviation of the radiocarbon dates explains partial overlaps between higher and lower lake-level events. The figure also shows a clear disparity in the distribution of data between both the histograms; the lower lake-level episodes appear better documented than the higher ones. This difference directly reflects changes in the lithology. The phases of low lake-level are often marked by an extension of peat or organic detritus accumulation in the near-shore areas (more material appropriate for radiocarbon dating), sometimes even by organic anthropogenic layers on archaeological sites well dated by tree-ring dates, whereas rises in lake-level are characterized by a deposition of more minerogenic sediments. Furthermore, due to the present-day state of available data, even the lower lake-level episodes between 9000 to 7500 cal. BP appear to be more weakly documented by comparison with those of the preceding and following periods.

in shape to those of ^{10}Be reconstructed from polar ice-sheets, the variations in both the isotopes are assumed to be primarily driven by changes in production and reflect variations in solar activity (Renssen *et al*. 2000). Finally, peaks of ice-rafting debris (IRD) from cores in the North Atlantic highlight IRD events punctuating the whole Holocene and marking cooling events (southward advections of cooler, ice-bearing surface waters). A comparison of this Holocene IRD record with the atmospheric residual ^{14}C and the GISP2–GRIP ^{10}Be records led to the conclusion by Bond *et al*. (2001) that a solar forcing mechanism underlies the North Atlantic IRD events.

In Figure 9.2 close correlations appear between the mid-European lake-level record and the other proxy data. Generally speaking, higher lake-level phases coincided with IRD events, ^{14}C and PCI maximums. Theses synchronicities indicate that varying solar activity has been an important forcing factor of Holocene climate oscillations over the North Atlantic area, and that climate conditions in mid-Europe strongly depend on teleconnections in a complex cryosphere-ocean-atmosphere system (Magny 1999). This conclusion agrees with results based on palaeoenvironmental and archaeological data from other European countries (van Geel and Renssen 1998).

Return to the prehistoric lake-shore villages

Sedimentological analyses of sediment sequences sampled on several lake-shore archaeological sites since the 1970s have shown that Neolithic and Bronze Age lake-shore villages coincided with phases of lower lake-levels in the sub-Alpine area. Figure 9.3 displays an indirect test of a possible link between the development of prehistoric lake-shore villages and fluctuations of lake-level induced by variations in solar activity. Using a collection of *c*. 150 tree-ring dates (Magny 1993a), the frequency of the Neolithic and Bronze Age lake-shore villages can be compared with the atmospheric ^{14}C record. The peaks in frequency of prehistoric lake-dwellings correspond to ^{14}C minima. This correlation suggests that a higher solar activity induced warmer climate and lake-level lowering, which in turn favoured the development of prehistoric lake-dwellings. However, the development of Neolithic and Bronze Age lake-shore villages depended not only on climate, but also on cultural factors (Magny 1993a; Wolf and Hurni 2002). The absence of lake-shore villages between 4360 (2410 BC) and 3750 (1800 BC) tree-ring years BP cannot be explained only by climatic factors. Indeed, Figure 9.2 shows that, except for a short rise at 4150–3950 cal. BP, the period 4800–3500 cal. BP was characterized by low lake-levels. These favourable lake conditions were synchronous with a long-lasting, and marked glacier retreat in the Alps (Gamper and Suter 1982). The cessation of the prehistoric lake-shore villages after 4360 tree-ring years BP coincided with the arrival of foreign populations (the so-called Bell Beaker group). The impact of cultural factors is also obvious in the absence of Neolithic and proto-historic lake-shore villages before 5900 and after 2750 cal. BP, whereas Figure 9.2 shows several periods of low lake-level before 5900 and after 2750 cal. BP.

Moreover, the climate oscillations reflected by changes in lake level had an impact not only on the prehistoric lake-dwellings, but also on changes in the culture of the sub-Alpine prehistoric groups. It is of note (Figure 9.3) that changes of culture within the Neolithic and Bronze Age periods most often occurred during phases of higher lake-level, i.e. cooler and wetter climatic conditions may have induced a destabilization of the former socio-economic equilibrium. An example is the study by Arbogast *et al*. (1996) of the development of lake-shore Neolithic villages at Lakes Chalain and Clairvaux in the Jura Mountains between 5700 and 4500 cal. BP. The archaeological data suggest a stronger sensitivity to bad weather conditions and an increased instability of former agricultural communities, which chose to develop cereal production and a crop-subsistence strategy to the detriment of grazing in response to the growth of the regional population. Thus, this model points to a complex interaction between changes in climate conditions, population density and subsistence strategy. The recurrent coincidences of natural, climatic variations with changes in cultural characteristics over the Neolithic and proto-historic periods in the sub-Alpine region support the possible impact of climate oscillations on cultural changes.

Towards a history of seasons

If the rhythm of climate oscillations partly explains the timing of the Neolithic and Bronze Age lake-shore villages in the sub-Alpine area, further investigations

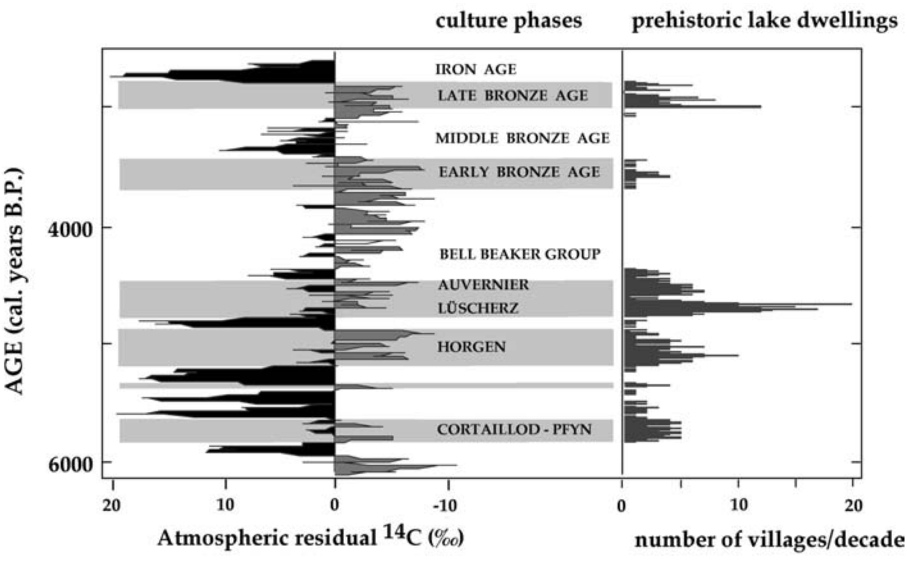

Figure 9.3 Comparison between the atmospheric residual ^{14}C variations (Stuiver *at al*. 1998) and the frequency of Neolithic and Bronze Age lake-shore villages in France and in Switzerland (Magny 1993a).

are needed for a better understanding of a possible impact of climate oscillations on former agricultural communities.

Various approaches have been developed today to quantify variations in climatic parameters during the Holocene period. Until now, in Europe, most information has been acquired from beetle, pollen and isotopes or even chironomid data. Pollen data offer the advantage of giving information not only on temperature, but also on precipitation: plant distributions respond to changes in summer warmth, winter cold and moisture balance. Generally speaking, the method reconstructing past temperature and precipitation from pollen data is to use modern analogues. The principle is to find, for each fossil pollen assemblage, several similar modern pollen spectra (modern analogues) on the basis of an appropriate distance index. The climate of these analogues is averaged to provide an estimate of the fossil assemblage climate. However, various reasons, in particular human disturbances of modern samples or lack of perfect modern analogues, are responsible for an exaggerated heterogeneity between the analogues. It is possible to reduce this by looking at the vegetation structure (biome) from which they originate (tundra, taiga, temperate deciduous forest, xerophytic wood/shrub, steppes, etc). The constraint by biome consists of (i) comparing the biome assigned to the analogues retained with the biome assigned to the fossil assemblage and (ii) rejecting the analogues for which the biomes are not consistent. An additional constraint is provided by lake-level reconstruction. Analogues giving a climate that was not compatible with the lake-level status were rejected. Thus, climate reconstruction is based only on those among the analogues which are coherent with each other (according to the biome) and with lake levels (Guiot *et al*. 1993).

The first results obtained from this method at Le Locle (Swiss Jura) and Saint-Jorioz, Lake Annecy (French Pre-Alps) document the first half of the Holocene period (Magny *et al*. 2001; Magny *et al*. in press). They indicate that phases of higher lake level coincided with an increase in annual precipitation, a decrease in summer temperature and a shorter growing season. Conversely, periods of lower lake level corresponded to a decrease in annual precipitation, an increase in summer temperature and a longer growing season (Figure 9.4). The reconstructed climatic parameters and the magnitude of the variations in summer temperature (*c*. 2°C) appear to be consistent with the mechanism governing the glacier advances and retreats, and the tree-limit variations in the Alps (Bortenschlager 1977; Patzelt 1985).

This general pattern may reflect alternate southward/northward displacements of the Atlantic Westerly Jet (Magny 1993b; Figure 9.4, lower panel). This scheme agrees with the synchronicity between phases of higher mid-European lake-levels, and high-latitude cooling phases such as are illustrated by the GISP2–PCI index (Figure 9.2). A southward position of the Atlantic Westerly Jet may have led to an enhanced cyclonicity and increasing precipitation over the European mid-latitudes (increase in the alimentation of mid-European lakes and Alpine glaciers). This general mechanism may explain both the desertion of the lake shores by prehistoric groups and the culture changes during climate cooling

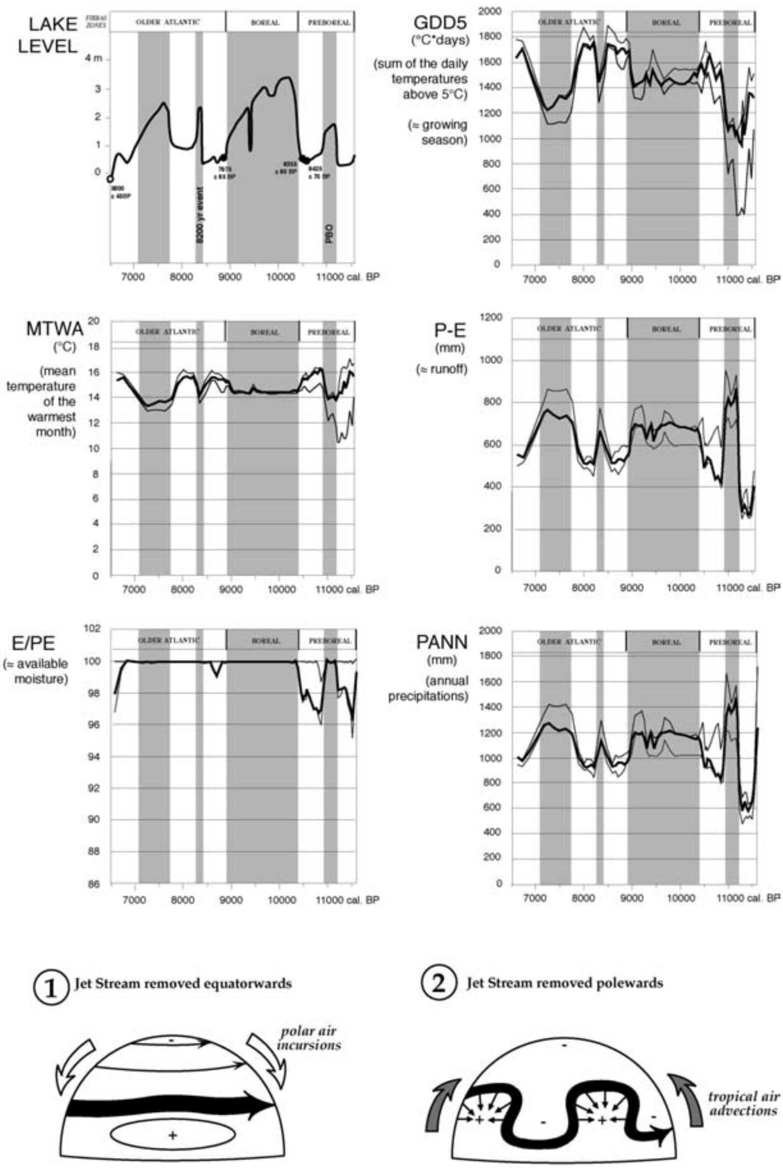

Figure 9.4 Top panel: climatic parameters reconstructed from pollen and lake-level data at Le Locle, Swiss Jura (Magny *et al*. 2001). Each reconstructed curve shows the mean value calculated over the analogues, the mean minimum and mean maximum. Bottom panel: general circulation patterns in the northern hemisphere. During the cooling phases (1), polar air incursions are accentuated in winter and the westerly winds are reinforced in summer. The warm phases (2) are marked by a weakening of the jet stream and more frequent tropical air advections towards mid-latitudes (Magny 1993b).

phases respectively due to higher lake levels (former lake-shore settlement sites flooded) and less favourable conditions for farming activity (destabilization of the former socio-economic equilibrium).

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10

BONES AS A KEY FOR RECONSTRUCTING THE ENVIRONMENT, NUTRITION AND ECONOMY OF THE LAKE-DWELLING SOCIETIES

Jörg Schibler

Introduction

Ludwig Rütimeyer (1825–1895) was the first scientist to study and publish animal bones from Neolithic lake-dwellings, and his publication *Untersuchungen der Thierreste der Pfahlbauten in der Schweiz* (1860) established modern Zoo-archaeology.

The profuse urban and road development which has taken place in Switzerland in the past 150 years has resulted in a large number of lake settlement discoveries. As result, a large amount of animal bones have been obtained and analysed. Due to the exceptional level of preservation below the water table large mammal bones are recovered in excellent condition and the bones of smaller animals, such as small birds, reptiles, amphibians and even fish, are also preserved. Many of the lake-dwelling sites have been precisely dated using dendrochronology and we know how long the villages were occupied. Therefore, compared to other regions the quality of information from lake-dwellings based on the animal bones benefits from the high density of sites analysed the excellent state of conservation and the opportunity for precision dating.

Since Rütimeyer (1860 and 1862) several authors have undertaken syntheses of the archaeozoological results from Swiss Neolithic lake-dwellings (Hescheler and Kuhn 1949; Hartmann-Frick 1969; Furger 1980: 161–77). Until the 1980s the results were grouped primarily by cultures, but since the development of more reliable dendrochronological and calibrated ^{14}C analyses from the 1990s, they have been grouped in a strict chronological order (Schibler and Suter 1990; Schibler and Chaix 1995). This grouping has proved more efficient for the economic and ecological interpretations of the data.

Database, methods of quantification and dating

Our study is based primarily on results from the Swiss Alpine foreland, including all information published on Lake Constance and the lakes in the French Jura over the last 25 years. At present around 130 Neolithic lake-dwelling sites with a total of about 250,000 diagnostic animal bones (Schibler and Chaix 1995) can be compared, whereas the Bronze Age only yielded 24 lake-dwelling sites with 30–40,000 identified animal bones (Schibler and Studer 1998) (see also Figure 10.1).

For the evaluation and comparison of species and animal groups only a percentage of the fragment numbers can be used. Our overview includes only sites in which more than 50 identifiable fragments were found. Only seven out of about 150 sites (Neolithic and Bronze Age sites) yielded less than 100 diagnostic bones. Most sites had more than 200 identifiable bones and around 90 sites had over 500, with a maximum of 16,931. For certain approaches the bone weight, the minimum numbers of individuals (MNI) or find concentrations of bones, are preferred to fragment numbers. However, these methods of quantification are not used for all sites.

Almost all the sites considered here have been dendrochronologically or ^{14}C dated. Only a few sites are typologically dated. The accuracy of the dating is important for the establishment of the correct chronological development.

Our archaeozoological data from Neolithic lake-dwelling settlements run from 4300 to 2500 BC cal. For the Bronze Age we have data for the seventeenth and sixteenth century BC cal. (late phase of Early Bronze Age) and for the eleventh to the ninth century BC cal. (Late Bronze Age). The number of terrestrial Neolithic sites with preserved animal bones is similar to that of the Bronze Age (about 20 sites).

Farmers or hunters?

The relationship between the number of domestic and wild animal bones fluctuated greatly between 4300 and 2500 BC cal. (Figure 10.2A and B). The proportion of domestic animals in particular fluctuated several times within this period, especially in eastern Switzerland. How can these be interpreted? Was disease responsible for killing most of the domestic animals, was hunting intensified or were both factors involved simultaneously? To answer these questions another method of calculation is necessary. We compared the bone-find concentrations instead of the percentages based on fragment numbers. Bone-find concentrations of domestic and wild animals do not influence each other, as percentages do. On the basis of the concentrations it is possible to decide whether there was an increase in the exploitation of either domestic or wild animls, or of both (Stöckli 1990). Our calculation of the concentration is not based on the volume of each layer, but on the number of bones per square metre in each settlement phase. This permits us to circumvent the problem of the determination of the exact volume of the layer and other problems such as the question of layer erosion or compression (Schibler *et al*. 1997b: 329). Settlement

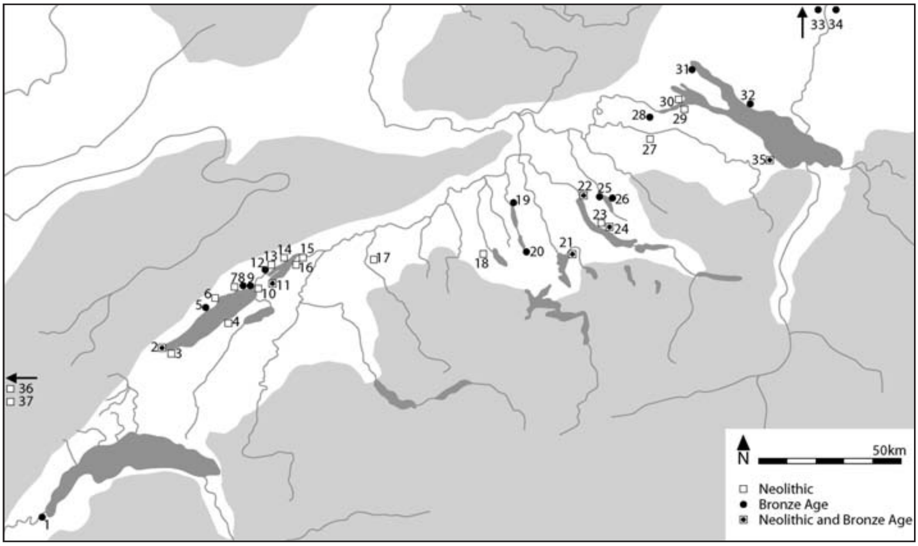

Figure 10.1 Distribution of the Neolithic and Bronze Age lake-dwelling sites in Switzerland and the adjacent area. (N) Neolithic, (B) Bronze Age. 1 (B) Genf-Eaux-Vives (Revilliod/Reverdin 1927); 2 (N,B) Yverdon-Garage Martin (Chaix 1976a); 3 (N) Yvonand station III (Chaix 1976b); 4 (N) Portalban-Les Grèves (Chaix *et al*. 1983); 5 (B) Cortaillod Est (Chaix 1986); 6 (N) Auvernier-La Saunerie (Stampfli 1976), -Brise Lames (Desse 1976), Port (Chaix 1985); 7 (N) St. Blaise-Bains des Dames (Stopp unpubl.); 8 (B) Hauterive-Champréveyres (Studer 1991); 9 (B) Marin-Epagnier-Le Chalvaire (Studer 1998); 10 (N) Thielle Wavre-Pont de Thielle (Chaix 1977); 11 (N,B) Vinlez-Strandboden (Marti-Grädel unpubl.), -Alte Station NW (Marti-Grädel unpubl.), -Hafeneinfahrt (Marti-Grädel unpubl.), -Grabung Strahm 1960 (Stampfli 1966), -Ländti (Stampfli unpubl.); 12 (B) Le Landeron-Les Marais (Chaix unpubl.); 13 (N) La Neuville-Chavannes (Marti-Grädel unpubl.); 14 (N) Twann (Becker/Johansson 1981, Becker 1981, Grundbacher/Stampfli 1977, Stampfli 1980); 15 (N) Nidau-BKW & Port-Stüdeli (Glass/Schibler 2000); 16 (N) Lattrigen VI and Sutz-Rüte (Glass/Schibler 2000, Marti-Grädel unpubl.); 17 (N) Seeberg-Burgäschisee Süd and SW (Boessneck/Jéquier/Stampfli 1963, Josien 1956, Stampfli 1964); 18 (N) Egolzwil 3 (Stampfli 1992); 19 (B) Hallwil - Rostbau (Steinmann 1923 and 1925); 20 (B) Hochdorf-Baldegg (Hescheler/Rüegger 1940); 21 (N,B) Zug-Vorstadt, -Sumpf (Rehazek/Schibler unpubl., Schibler/Veszeli 1996); 22 (N,B) Zürich-Mozartstrasse, -Seefeld, -Pressehaus, -AKAD, -Mythenschloss (Hüster-Plogmann/Schibler 1997), Zürich-Grosser Hafner (Schibler unpubl.), Zürich-Alpenquai (Wettstein 1924); 23 (N) Feldmeilen-Vorderfeld (Schibler/Veszeli 1998, Förster 1974, Eibl 1974); 24 (N,B) Meilen- Rohrenhaab (Sakellaridis 1979), -Schellen (Schibler unpubl.), -Obermeilen (Kuhn 1935); 25 (B) Fällanden-Riedspitz (Schibler unpubl.); 26 (B) Greifensee-Böschen (Schibler 1987); 27 (N) Gachnang-Niederwil-Egelsee (Clason 1991); 28 (B) Uerschhausen-Horn; 29 (N) Steckborn-Turgi, -Schanz (Marhert (1985a and b); 30 (N) Hornstaad-Hörnli I (Kokabi 1990); 31 (B) Bodmann-Schachen (Kokabi 1990); 32 (B) Hagnau-Burg (Kokabi 1990); 33 (B) Buchau-Wasserburg (Kokabi 1990); 34 (B) Bad Buchau-Forschner (Kokabi 1990); 35 (N,B) Arbon-Bleiche 3 (Deschler-Erb *et al*. 2002), -Bleiche A (Kuhn/Güller 1946); 36 (N) Lac de Chalain (Arbogast 1997); 37 (N) Clairvaux-les-lacs (Arbogast/Pétrequin 1993).

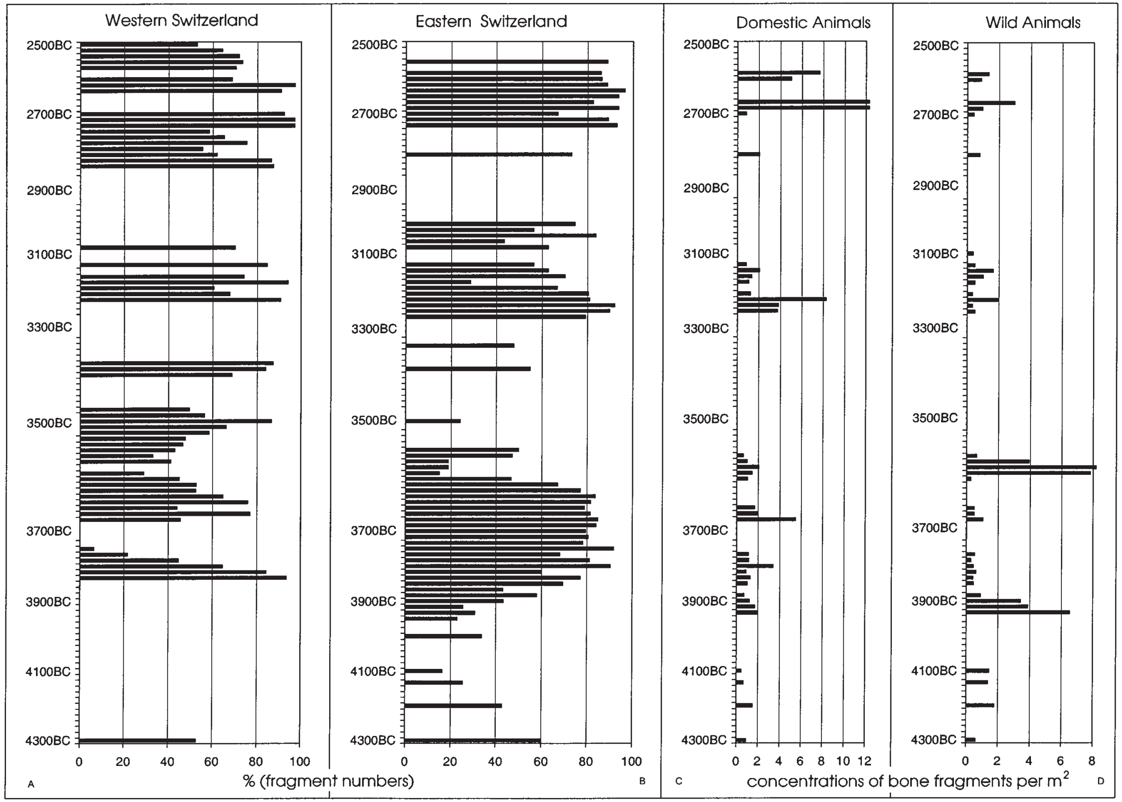

Figure 10.2 Importance of domestic animals according to the frequencies of bone fragments for the Neolithic lake-dwelling settlements in the western (A) and eastern (B) part of Switzerland and the concentrations of domestic (C) and wild (D) animal bones per square metre and settlement phase for the Neolithic settlements in Zurich.

phases normally last around 20 years and are therefore more or less comparable. Because this is not an exact calculation of the concentrations, small differences are not considered. The data necessary for these calculations was available only from the Neolithic villages of Zurich and Twann (Schibler *et al*. 1997a; Stöckli 1990). The results clearly show that if percentages of wild animal bones are high, concentrations of wild animal bones are high too, but the concentration of domestic animals remains the same (Figure 10.2 A–D). This is evident during two periods, during the fortieth and thirty-seventh centuries BC. During these periods people hunted a lot more wild animals, especially red deer, but slaughtered the same number of domestic animals as in the periods before or after. This means people 'produced' and consumed more meat. During the thirty-seventh and thirty-sixth centuries all lake-dwellings in the Swiss midlands and the French Jura show high proportions of wild animals, especially red deer. The proportions of wild animal bones depend on the different geographical areas. We find the largest amount of hunted animals at Clairvaux MM V in the French Jura (Arbogast and Pétrequin 1993), with over 90 per cent. This village is situated at an altitude of about 500 m above sea level. Smaller proportions of wild animals are found in the settlements at Lake Bienne and Lake Neuchâtel, in the region where vineyards grow today. Settlements from the thirty-seventh and thirty-sixth centuries in Zurich and Zug again yield higher values of wild animal bones. The fact that within a certain time span all settlements have high proportions of wild animals with regional fluctuations, suggests a correlation with climatic conditions.

If we use the ^{14}C-concentrations as proxy data for climatic conditions (Gross-Klee and Maise 1997) we find a correlation between high ^{14}C-concentrations and high proportions of hunted animals (Hüster-Plogmann *et al*. 1998). This correlation shows that during unfavorable climatic conditions, people hunted more intensively. Furthermore, if we also look at the archaeobotanical results we find strong evidence for a higher proportion of collected plants. Plants with calorie-rich seeds or fruits, like the hazel nut (*Corylus avellana*), turnip (*Brassica rapa*) or white goosefoot (*Chenopodium album*) are, for example, found in the thirty-seventh-century villages of Zurich (Mozartstrasse, layers 4 and 5). These villages also have high proportions of hunted animals and low concentrations of cereals (Brombacher and Jacomet 1997: 242 and 284; Schibler *et al*. 1997a: Figure 7).

We can therefore conclude that during unfavourable climatic conditions, which could last over 10 years and even several decades, farmers suffered an increasing number of crop failures. If they could not produce enough carbohydrates (cereals), they had to substitute the missing calories with calorie-rich seeds or fruits from collected plants and from the meat of hunted animals.

Fluctuation of the proportion of wild animal bones can also be discerned for the Bronze Age lake-dwellings, implying the existence of similar problems. If we look at the relationship between the amount of domestic and wild animal bones in the mineral soil sites, however, we find no site with over 18 per cent wild animals. In most of these sites only 2 to 5 per cent wild animal bones could be determined. One might interpret this as reflecting a different economic basis.

However, the discovery of a mineral soil site from the very early Iron Age in the upper Rhine valley (Seifert 1999) covered by more than three metres of debris from a landslide and where more than 60 per cent of the bones came from wild animals suggests another interpretation. Many mineral soil sites were destroyed by erosion. This erosion occurred more frequently during unfavourable climatic conditions with intensive precipitation, therefore, settlement layers which were deposited during good climatic conditions were more likely to be preserved. When climatic conditions were favourable, hunting was less important and consequently predominantly bones from domestic animals were deposited.

Red deer antler: an intensively exploited raw material

During the Neolithic lake-dwelling period, red deer antler was intensively used to produce sleeves; an intermediate piece placed between the valuable wooden handles and the stone blades of axes and adzes. Sleeves marked a technical innovation intended to absorb shock and protect the blade and the handle. Sleeves came into use around 4000 BC but were critically important only from around 3600 BC cal. onwards.

Neolithic craftspeople primarily used collected shed antler rather than antler from hunted red deer. This was a clever method of raw material management (Schibler 2001). As a result of the climatic deterioration during the thirty-seventh century (which lasted over 60 years), farmers in the Zurich region hunted red deer intensively (63–7 per cent). At first they killed mainly adult males, but as time went by, they were also forced to kill younger individuals. After more than 60 years of intensive hunting, red deer disappeared from the Zurich region and perhaps over an even larger area towards Lake Constance (Hüster-Plogmann and Schibler 1997: 93).

Unfortunately, no settlements dating from the second half of the thirty-sixth century until the thirty-fourth century have been found, in either region. Around Zurich, almost no antler artefacts or sleeves are present in the settlements dating from the thirty-fourth and thirty-third centuries. In Arbon-Bleiche 3, which dates between 3384 and 3370 BC cal., many antler artefacts were excavated but again no sleeves were found. It is possible that intensive hunting of red deer during the thirty-seventh and thirty-sixth centuries led to the extinction of this animal over an even greater area. This forced craftspeople to change their hafting techniques and return to direct hafting of the stone blades in wooden handles. This technological tradition must have lasted for a long period, as we cannot explain why at Arbon-Bleiche, where more than 700 antler artefacts were found, there was not a single sleeve dating from the thirty-fourth century BC (Deschler-Erb *et al*. 2002).

The exploitation of domestic animals

Just like other European Neolithic peoples, the lake-dwellers had cattle, sheep, goats, pigs and dogs as domestic animals. At the end of the Neolithic lake-dwelling period, the domestic horse appears, although bones of this animal are only rarely found even in the Bronze Age. Horses were almost certainly not kept for meat production, and instead used for riding or for traction (Hochuli and Maise 1998: 301–3). Rock carvings from 'Val Camonica' in northern Italy provide plausible proof (Anati 1994: 167; Schibler and Studer 1998: 178).

If we compare the frequencies of cattle, sheep/goat and pig bones it is apparent that in Neolithic and Bronze Age lake-dwellings cattle were the most frequent domestic animal (Schibler and Chaix 1995: Figure 48). There are three exceptions: (1) the early phase of the Neolithic lake-dwellings at the end of the fifth millennium; (2) the period of the Horgen Culture, and (3) the Bronze Age lake-dwellings of western Switzerland.

At the earliest Neolithic lake-dwellings only 20 per cent of bones belonged to cattle, whereas later, they constituted between 40 and 80 per cent of the domestic animals bone assemblage. This could lead to the conclusion that during this early period, in which only few and small villages are known and the exploitation of the environment was less intensive, the landscape was densely forested and therefore there was not enough space for large cattle herds. If we look at the find densities of cattle bones from the Zurich area, the lowest concentration in the villages dates from the fifth millennium (Figure 10.3 and also 10.4). These early lake-dwelling farmers could also have been influenced by economic traditions. Both the Egolzwil and the Cortaillod Cultures were influenced by Mediterranean cultures in which sheep and goat were traditionally of greater importance. There are two possible reasons for this remarkably low frequency of cattle in the earliest lake-dwellings. A comparison of the percentages and the concentration values of cattle bones show that the lower percentages of cattle bones during the Horgen Culture are due to the greater quantity of pig bones (Figure 10.3). At the same time, the concentration values of cattle bones in the Horgen villages remained the same as the value during the earlier Pfyn village period. This means that in the Zurich region cattle herds must have been the same size in the Horgen period as they were in the late Cortaillod and the Pfyn Cultures.

During the Corded Ware Culture the concentrations of cattle bones increased (Figure 10.3). We deduce that an increase in the availability of larger open areas (as have been demonstrated by archaeobotanical results: see Chapter 11) provided a less costly fodder resource for cattle, which in turn, led to the increasing popularity of cattle farming. Cattle were used as work animals, as the osteological results demonstrate. Bulls were castrates and used as traction animals (Hüster-Plogmann and Schibler 1997: 61–3). The frequent evidence of wooden wheels from the Corded Ware period suggests that goods and materials were being transported over greater distances in the area around the settlements. Osteological results as well as the discovery of a wooden yoke demonstrate that this mode of transport was already used at the beginning of the Horgen Culture (Schibler 1997; Leuzinger 2002: 106).

In the Bronze Age lake-dwellings of western Switzerland the frequencies of cattle bones are significantly lower than in eastern Switzerland (Schibler and

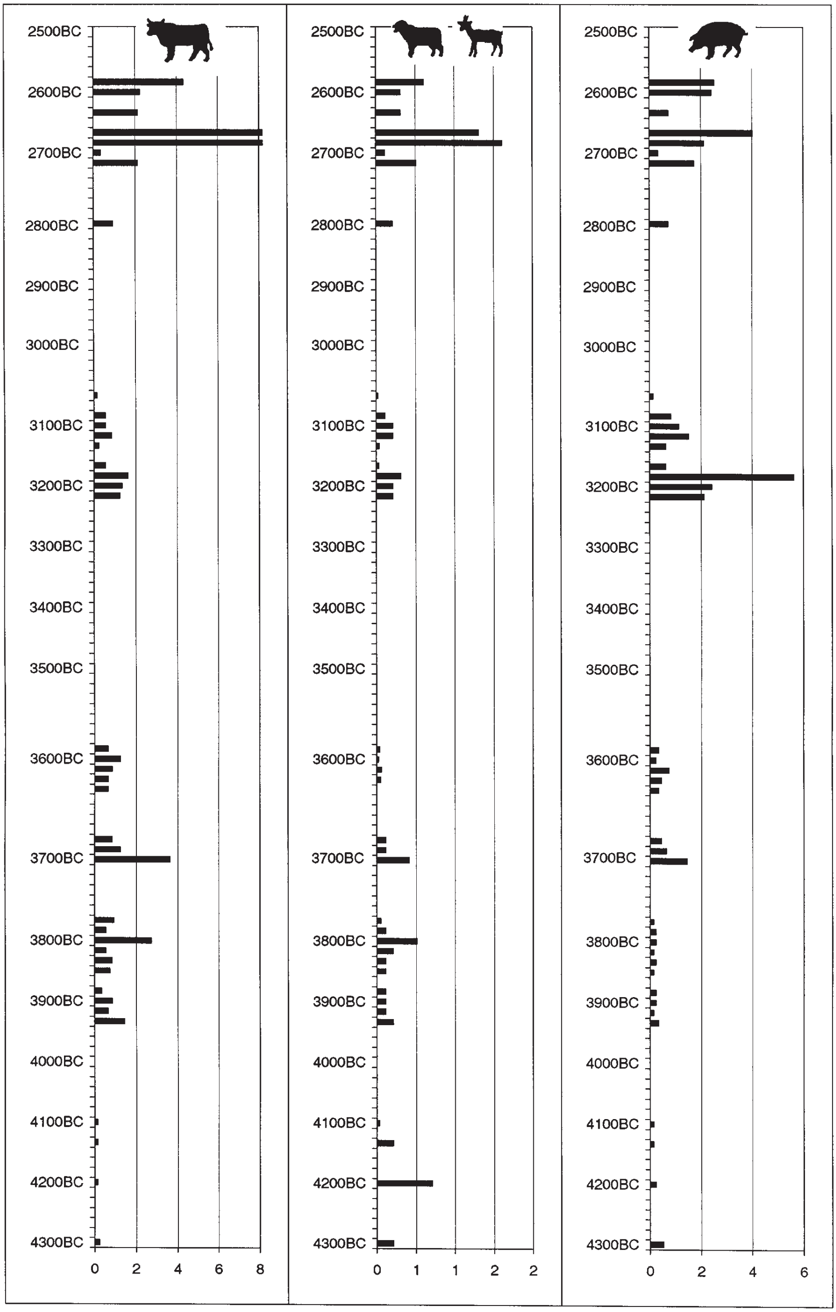

Figure 10.3 The importance of domestic animals – cattle, sheep/goat and pig – according to the concentration of bone fragments per square metre and settlement phase for the Neolithic settlements in Zurich.

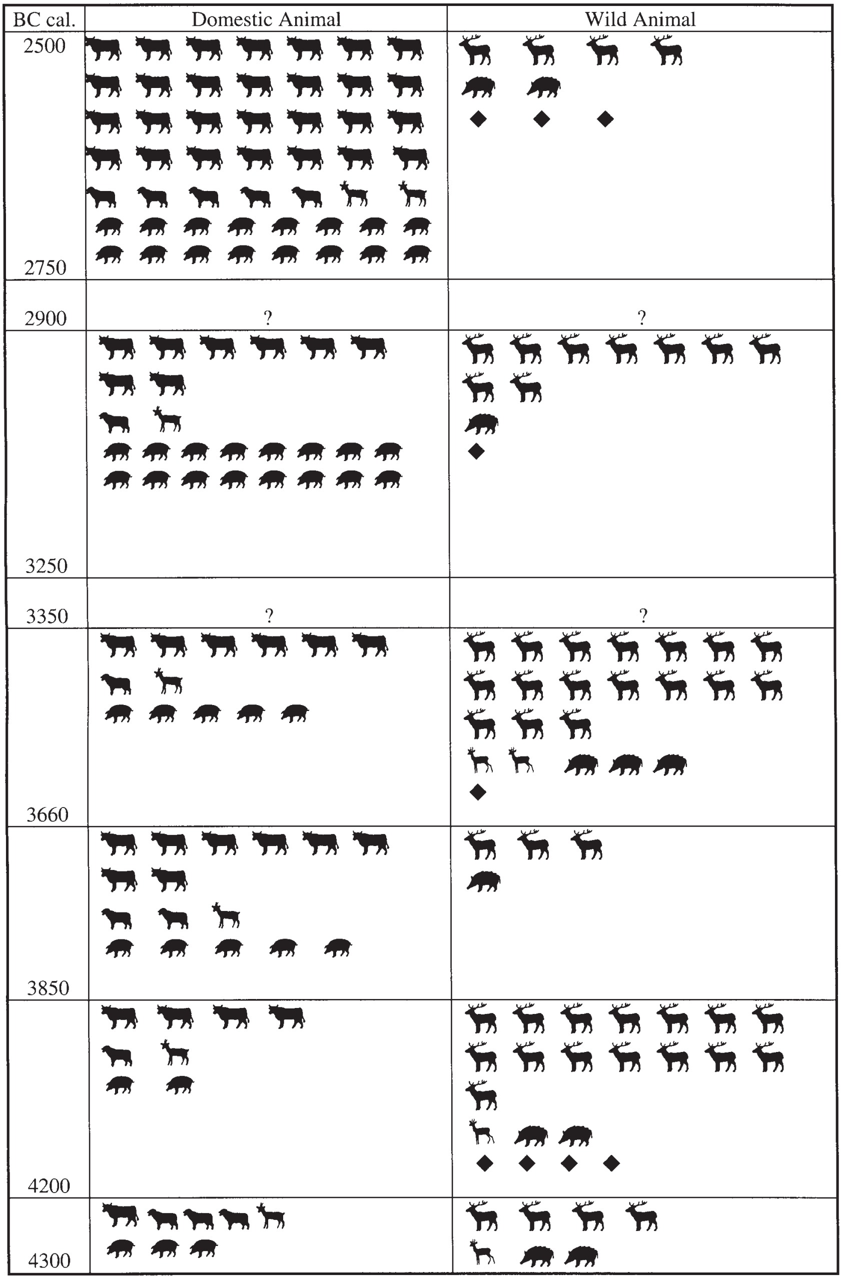

Figure 10.4 Chronological changes in animal husbandry and hunting in the Neolithic lake-dwelling settlements of Switzerland. Synthesis of the bone concentrations (fragments per square metre and settlement phase) and the frequencies of bone fragments (*n* per cent).

Studer 1998: 179). Bone concentration values are not available, but it is argued that the reduced percentage of cattle bones in western Switzerland is due to steeper topography, and therefore, the exploitation of sheep and goats, animals suited more to that environment.

The highest percentages of sheep and goat bones (60 to 70 per cent) are found in the earliest villages of the Egolzwil and Cortaillod Cultures (Schibler and Chaix 1995: Figure 52).

If we compare the concentrations of sheep and goat bones in the region of Zurich, significantly higher values are found only in the Corded Ware villages (Figure 10.3). This result coincides with an increase of the mean size of the sheep and with a higher proportion of animals that were slaughtered at an older age (Hüster-Plogmann and Schibler 1997: 81–3). During the same period buttons and needles made from bone or antler were found for the first time. This could represent the earliest evidence for the introduction of woolly sheep and the use of wool for producing textiles.

During the Bronze Age, goat and particularly sheep were more frequent. In the villages of western Switzerland up to 60 per cent of the bones of domestic animals derived from sheep. During the same period the frequencies of macro-remains from linen decreased (see Chapter 11). This is a clear indication that woollen textiles became much more important than linen in the Bronze Age lake-dwellings.

With the botanical macro-remains, bone artefacts and animal bones, an attempt to reconstruct the development of the clothing of the lake-dwelling people can be made. Linen macro-remains became frequent from the thirty-ninth century on. As a result, a special type of comb made of several halved and pointed ribs from cattle or red deer, presumably used to separate linen fibres, is more frequently found on sites of this period. This was one of the most important tools in the Horgen villages. During the Corded Ware Culture, the period in which the first woolly sheep were present, this tool decreased in popularity. During the Bronze Age linen macrofossils are rare and sheep far more important. These facts indicate that during the oldest period of lake-dwellings, up until the thirty-ninth century BC, leather and bast fibres were principally used for the production of clothing, resulting in the gradual introduction of linen fibres for the production of textiles. Linen exploitation reached a peak between 3400 and 2800 BC cal. After this period people started using wool. During Bronze Age lake-dwellings, woollen textiles were far more important than before. Linen textiles were still produced, but they were of less significance than during the Neolithic.

Pigs were important for the first lake-dwelling farmers. For the period between 4300 and 4000 BC cal. 30–40 per cent of the domestic animal bones derived from pigs (Schibler and Chaix 1995: Figure 54). Perhaps this is because pigs could be easily fed in the forests and by household waste. Pigs were less important from 4000 BC cal. on, especially in western Switzerland with frequencies of pig bones at around 20 per cent. In eastern Switzerland the frequencies of pig bones slowly increased during the later Pfyn culture until 3500 BC cal. In the Horgen Culture pig was usually the most frequent animal bone and reached proportions of up to 70 per cent, but the percentage decreased during the Corded Ware Culture (Schibler and Chaix 1995: Figure 54). However, the concentrations of the bones in the settlements from the Zurich region (Figure 10.3) provide evidence that pigs were kept equally intensively during the Corded Ware and the Horgen Cultures. Methods of quantification, percentages on the basis of bone fragments and find concentrations demonstrate that the intensive exploitation of domestic pigs during the Horgen and Corded Ware Cultures had slowly developed during the Pfyn Culture in the eastern part of Switzerland, whereas the influence of the Horgen Culture in western Switzerland caused the interest in pig husbandry to increase in that region.

But why did domestic pigs become so important during the second half of the fourth millennium? Palynological analyses as well as evidence from the wood anatomy of building timber suggest that in the Zurich area from 3600 BC cal. onwards there was an increase in forest management (coppice-with-standards). High oak-pollen values suggest that there were freestanding oaks in the shrub-rich areas of regenerating woodland. This improved the feeding opportunities for pigs, which explains the significantly higher frequencies of pig bones in the Horgen levels. The intensification in cultivation during the Horgen Culture, which has been established archaeobotanically, provided additional sources of feed for the pigs (Brombacher and Jacomet 1997).

During the Bronze Age, proportions of pig bones are lower than in the Neolithic period (between 3400 and 2500 BC cal.). This is due primarily to the greater importance of sheep and goats. It seems reasonable to assume, therefore, that pig husbandry had the same importance during Bronze Age as during the third millennium BC.

Dog bones were recovered in all lake-dwellings. Usually they were not fragmented and only few had cut marks. In the Bronze Age there are single villages like Hauterive-Champréveyres where dog bones with many cut marks provide evidence of the systematic exploitation of dogs for meat (Studer 1989). Neolithic and Bronze Age dogs were of gracile stature and, especially the Neolithic dogs of very uniform size. The withers height of the Neolithic dogs, varied between 41 and 47 cm whereas the Bronze Age dogs are taller, varying from 49 to 64 cm.

In general, only 5 per cent or less of the domestic animals bones is from dogs. They are more frequent in only two phases: the late Cortaillod Culture in western Switzerland during the thirty-seventh and thirty-sixth centuries BC cal., and the earlier Horgen Culture in eastern Switzerland until the thirtieth century BC. During the late Cortaillod Culture in western Switzerland special pendants made from metapodials from dogs were fashionable, but they disappeared after the thirty-fourth century BC (Schibler 1981). From this time on they appear in the eastern part of Switzerland during the early Horgen Culture. We can therefore find a correlation between an increasing proportion of dog bones and a fashion consisting of dog metapodial pendants in both parts of Switzerland. Dogs definitely played an important role in the lake-dwellers' everyday life, but whether or not they had religious significance is difficult to discern.

History of the environment and fauna

Red deer were the most important animal throughout all the prehistoric periods in the Alpine foreland. As explained above, several economic crises were responsible for intensive hunting during the Neolithic and Bronze Age. This resulted in a depression in the red deer population from the end of the Neolithic period onwards.

Other big ruminants like aurochs or elk were clearly less important game animals for the lake-dwelling hunters. Bones of these two species are found significantly less frequently in villages after 3400 BC cal. and are almost absent in the Bronze Age settlements. From the botanical studies we know that the lakeside dwellers regularly used all the natural areas of grassland as well as the herb-rich undergrowth of deciduous and wet woodlands in the immediate and more distant areas around the settlements, probably as pastoral land for cattle. As these locations would have also been the preferred pastures of the aurochs and elk, food competition between domestic and wild cattle and elk arose. This, as well as the regular presence and exploitation of the above-mentioned biotopes by people and their domestic animals, led to a decrease in the population density of aurochs and elk in the areas around the settlements. Hunting alone, which on the basis of our figures could not have been very intensive, is unlikely to have led to a decrease in the population of these large herbivores (Schibler and Steppan 1999; Hüster-Plogmann *et al*. 1999).

The study of other species of wild animals also indicates the gradual increase in human impact on the Neolithic environment. Signs of the thinning and wholesale destruction of the forest in the area around the settlements can be found in the very low and discontinuous presence of badger bones in the settlements after 3600 BC (Schibler and Jacomet 1999). This shy woodland animal clearly appeared more regularly and in greater frequencies in the settlement layers before 3600 BC. In contrast we find noticeably higher frequencies of fox and hare bones in the assemblage from latest settlements of the Corded Ware Culture, from around 2800 BC. Both animals prefer well-structured, open woodland with woodland edge biotopes and adjoining open fields. This type of landscape apparently became so important during the Corded Ware Culture at Lake Zurich that it is even reflected in the wild fauna. The different species assemblages of avifauna, as revealed by the bird bones, also suggest that there was a gradual shift from a relatively dense, closed woodland biotope, to a more open, more structured wooded landscape, with larger open areas (Schibler and Jacomet 1999). Bird species typical of open woodland as well as the indicator species of open fields appear only irregularly and rarely in the settlements before 3600 BC, whereas later, it seems they were hunted regularly and in higher frequencies.

The human impact can also be demonstrated with the change in bird species. From around 3700 BC cal. onwards bird species which prefer eutrophic water and nest in the reed belt became more frequent. This indicates the increasing human impact (clearings, settlement waste) that led to the eutrophisation of the lakes, which indeed, is the precondition for the growth of the reed belt (Schibler and Jacomet 1999).

Fish and amphibians

Fish must have constituted a substantial part of the diet of lake-dwelling people. A number of finds such as hooks and harpoons made from bones or antler, fishing nets, net floats and weights demonstrate the importance of fishing in the lake-dwelling villages.

Unfortunately, there are not many lake-dwelling excavations with systematic sampling and determination of bones from small animals like fish and amphibians. As far as the Neolithic sites are concerned, there are samples from the French Jura site Chalain, from the Zurich region and from Lake Pfaeffikon, a small lake near Zurich. However, not many samples from these regions have been analysed. The most important site for small animal bones is Arbon-Bleiche 3 at Lake Constance where many samples were taken and analysed. Most of the information on fish for Bronze Age villages comes from Hauterive-Champréveyres on Lake Neuchâtel. If no soil samples are taken and analysed, only hand-collected fish bones will be represented. Because excavators can only recognize objects of a certain size only bones from bigger fish species are present. This explains why in sites without soil sample analysis, pike is best represented.

By comparing the results found in the soil samples from the sites in Zurich with Arbon-Bleiche 3, one can notice that two different fishing techniques were used. In all the Neolithic villages in Zurich, fish were caught mainly in the shore region. Therefore perch (*Perca fluviatilis)*, pike (*Esox lucius*), minnows (*Cyprinidae*), whitefish (*Salmonidae*) and catfish (*Silurus glanis*) could be ascertained. In Arbon-Bleiche 3 where even scales were preserved, almost 60 per cent of fish remains derived from whitefishes (*Coregonus*), which must be caught in open water. At the small Jura lakes of Chalain and Clairvaux, at an altitude of above 500 m above sea level, trout was the main catch. In the Bronze Age at the Lake of Neuchâtel it seems mainly that perch and pike were the basis of the catch. Aside from these two species only a few remains from cyprinids and catfish were found.

In the soil samples frog bones were recovered along with the fish remains. As the analyses of the frog bones from Arbon-Bleiche 3 has shown, only one species, the common frog (*Rana temporaria*) was selected and presumably eaten. The exploitation of this frog species is also in evidence on Neolithic sites in the French Jura.

Conclusions

This chapter has shown the excellent state of preservation, the precision of the dating and the possibility of close interdisciplinary research, which make the lake-dwellings such outstanding archaeological resources. A crucial role is played by archaeozoology, which by using the phenomenal results obtained from the lake-dwelling sites can also provide ideas and explanations for terrestrial sites.

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11

ARCHAEOBOTANY

A vital tool in the investigation of lake-dwellings

Stefanie Jacomet

Introduction: the state of research

The first investigations of plant material from lake-dwelling sites took place soon after the discovery of the lake-dwellings in 1854. It was Prof. Oswald Heer (1809–83) from Zurich University who recognized the importance of the investigation of plant remains from archaeological sites for the reconstruction of the diet and environment of prehistoric people (Figure 11.1). This is illustrated by the following citation from the first publication, concerning mainly the site of Robenhausen at Lake Pfäffikon, near Zurich:

> Seit der Veröffentlichung der Untersuchungen des Hrn. Dr. F. Keller über die Pfahlbauten dürfte es Jedermann bekannt sein, dass die ältesten, bis jetzt bekannten Bewohner unseres Landes an den Seen gelebt haben . . . Mögen auch diese Wasserdörfer nicht die alleinigen Wohnstätten … gewesen sein, . . . so unterliegt es doch keinem Zweifel, dass sie für längere Zeit bewohnt waren . . . Es geht dies aus der grossen Masse von Küchenabfällen hervor, welche man im Schlamme zwischen den Pfählen gefunden hat . . . Aus diesen mit grosser Sorgfalt gesammelten und untersuchten Resten wurden die alten Pfahlbauten geistig wieder aufgebaut, so dass wir ein deutliches Bild von denselben uns verschaffen können.
>
> (Heer 1865: 1)

Heer was the first, but many later researchers also recognized that the material from the lake-dwellings allowed many more insights into the daily life of prehistoric societies than did the usual deposits because the preservation of the organic material is so good, due to the water-logging of the sediments. In a single litre of sediment, several thousand seeds and other material such as cereal chaff can be present. However, the state of preservation is not the same everywhere, and this can cause methodological problems in evaluating the data obtained. This was first noticed in the 1980s by researchers such as Jacomet *et al*. (1989: 59).

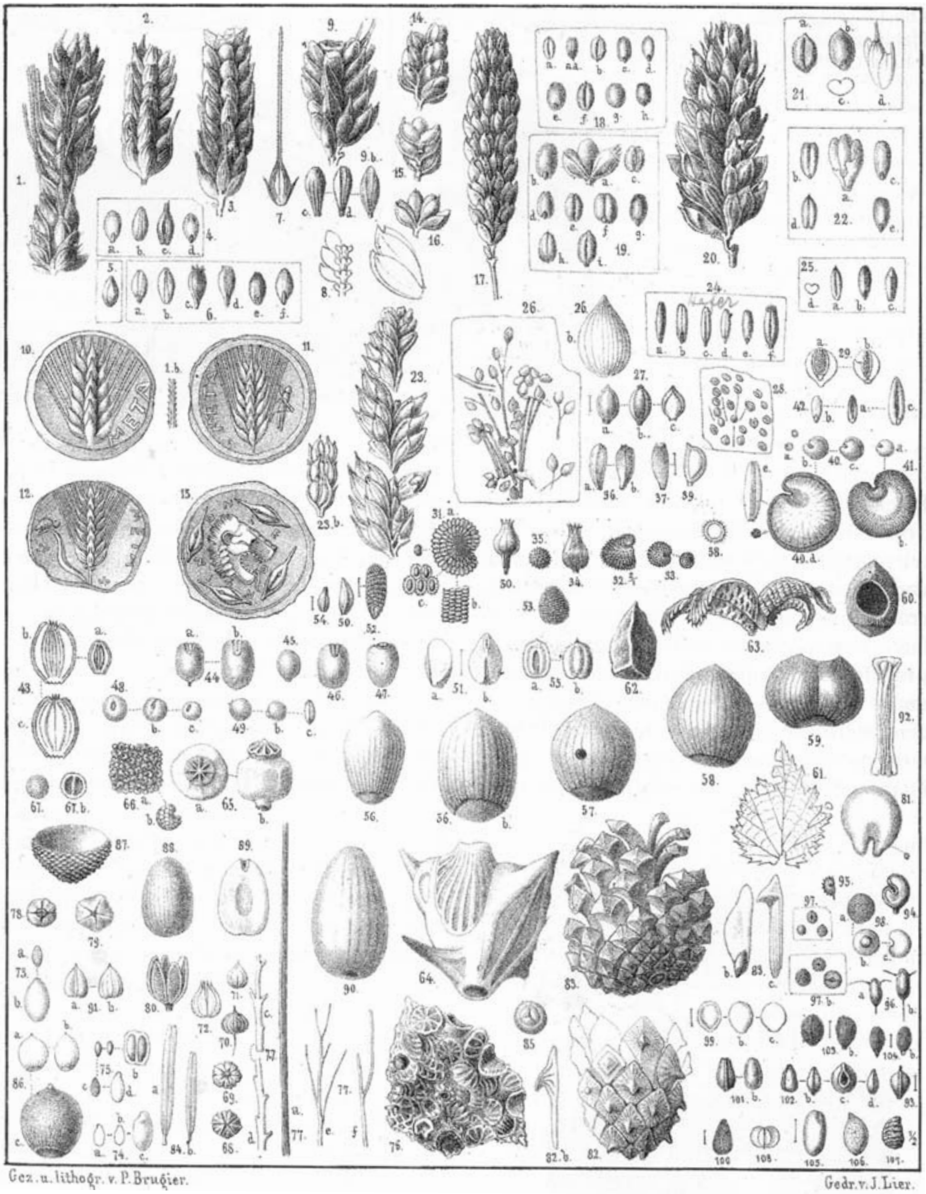

Figure 11.1 First illustration of plants from lake-dwelling sites (from Heer 1865).

Since Heer, the plant remains from many lake-dwellings have been investigated. If we take into consideration only the investigations of the last *c.* 35 years, where at least semi-quantitative investigation methods were applied, over 90 Neolithic and in addition around 20 Bronze Age settlement layers have been studied in the northern Alpine region (Figure 11.2). Most of the investigations were carried out in the city of Zurich and its surroundings. The state of research in regions south of the Alps is much poorer, and a proper compilation of the data is not possible. One of the big advantages of waterlogged preservation is the possibility of obtaining precise dating by dendrochronology. We have, therefore, the opportunity to compare even very short settlement phases with each other. The oldest archaeobotanical data from lake-dwellings reach back to the late fifth millennium cal. BC. Unfortunately, the oldest phases are not dendrochrono-

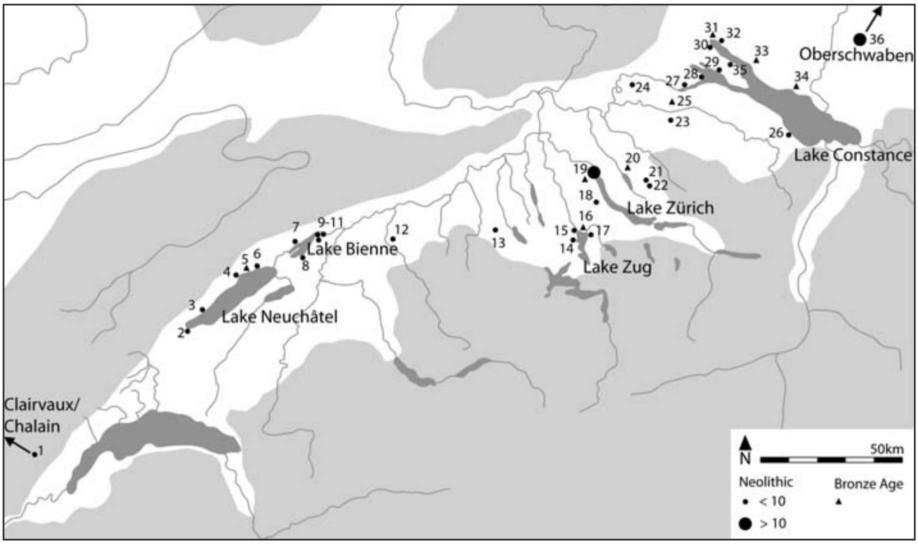

Figure 11.2 Map with Neolithic and Bronze Age sites of a part of the northern Alpine lake-dwelling area (mainly Switzerland). Settlement layers with archaeobotanical investigations are marked with points (Neolithic sites; small dots = under 10 settlement layers investigated, large dots = over 10 settlement layers investigated) or triangles (Bronze Age sites). Neolithic sites date between 4300 and 2400 cal. BC, Bronze Age sites between 1900 and 850 cal. BC 1 different sites at the lakes Clairvaux and Chalain (French Jura); 2 Yverdon, Avenue des Sports; 3 Concise-Sous-Colachoz; 4 Auvernier; 5 Hauterive-Champréveyres; 6 St. Blaise; 7 Twann; 8 Lüscherz; 9 Lattrigen (inkl. Sutz); 10 Port; 11 Nidau BKW; 12 Burgäschisee-Süd; 13 Egolzwil; 14 Risch-Oberrisch; 15 Cham (Eslen, St. Andreas); 16 Zug-Sumpf; 17 Zug-Vortstadt; 18 Horgen; 19 Zürich; 20 Greifensee-Böschen; 21 Pfäffikon-Burg; 22 Robenhausen; 23 Gachnang-Niederwil; 24 Thayngen-Weier; 25 Uerschahusen-Horn; 26 Arbon-Bleiche 3; 27 Wangen; 28 Hornstaad; 29 Allensbach; 30 Bodman; 31 Bodman-Schachen; 32 Sipplingen; 33 Unteruhldingen; 34 Hagnau-Burg; 35 Wallhausen; 36 several sites in the region of Federsee/Oberschwaben (Alleshausen, Oedenahlen, Reute, Stockwiesen, Torwiesen, Aichbühl, Riedschachen, Wasserburg Buchau).

logically dated; calibrated ^{14}C dates for sites of the Egolzwil Culture range between 4380 and 4280 cal. BC. This is the oldest known lake-dwelling 'culture' and sites are known from Lake Zurich, the Wauwiler Moos and now from Lake Zug. The latest Neolithic lake-dwelling phases from which plant remains have been analysed represent a late phase of the Corded Ware Culture (Schnurkeramik), the so-called Auvernier Cordé. The dates are around 2450 cal. BC (Gross-Klee and Hochuli 2002; Schlichtherle 1997; see also Figure 11.2) The oldest Bronze Age lake-dwelling sites from which plant remains have been analysed date back to the nineteenth century BC; these are the early Bronze Age layers from Zürich-Mozartstrasse, which were recently re-dated (Conscience 2001). The latest Bronze Age lake-dwelling phases date into the ninth century cal. BC and are situated at different lakes in the surroundings of the Alps (Hochuli *et al*. 1998: 17).

If we just consider the number of sites investigated, one gets an impression of a very thorough state of research. However, in reality, this is not the case. The methods applied have been very heterogeneous and even during the last decade there was no uniform research strategy. Thus, from the over 90 Neolithic sites, only around 35 have been investigated to a level that allows the data to be used quantitatively to calculate seed concentrations or do statistical analyses (Jacomet and Schibler in press). The data from other sites can be used only in the sense of presence or absence of given taxa. Additionally, almost all lake-dwellings were excavated during rescue excavations, therefore, the archaeobotanical researchers did not undertake a systematic 'sampling of the landscape'. Spots with intensive investigation result mainly from the fact that there are cities such as Zurich with much redevelopment. Motorways or railways have been built beside other lakes and have created the need for archaeological investigations in these places as well. Since the late 1960s the number of sites investigated is so large, however, that at least some tendencies can be seen, but there is another problem: the lakeshores were not used as settlement areas in all the epochs between around 4300 and 850 cal. BC. We have some time-slices characterized by dense settlement activity as, for example, between 3900 and 3600 cal. BC, but there are others from which hardly any settlements are preserved, for example after around 3600 cal. BC until 3250 cal. BC (Stöckli *et al*. 1995: 19; Schlichtherle 1997; Hochuli *et al*. 1998). Thus, very few archaeobotanical investigations have been undertaken outside the lake-shore areas.

The most recent syntheses of the data on plant remains from Neolithic lake-dwelling sites north of the Alps were made by Jacomet *et al*. (1989), Brombacher (1995) and Brombacher and Jacomet (1997). The author recently reviewed the state of research on Bronze Age lake-dwelling sites in the same region (Jacomet *et al*. 1998). Unfortunately, there is no up-to-date, systematic and quantitative compilation of the data. This is mainly due to the high number of recent projects and the little time available for analyses. Recent studies have been carried out all over the northern Alpine region. Amongst them we have the thirty-fourth-century village Arbon-Bleiche 3 on the Swiss side of Lake Constance (Hosch and

Jacomet 2001; Jacomet *et al.* in press); the settlement of Horgen Scheller on Lake Zurich and that of Pfäffikon-Burg, on Lake Pfäffikon, both dating to the thirty-first century cal. BC (Achour-Uster *et al.* 2002). Another inportant lake-dwelling site recently researched is the late-fifth-millennium BC settlement of Cham-Eslen on Lake Zug (Gross-Klee and Hochuli 2002; Martinoli and Jacomet 2002). Investigations at Hornstaad-Hörnle, on the German side of Lake Constance, which were undertaken from the 1980s onwards were recently published by Maier (2001). New results have also been published on one of the most prolific wetland areas in archaeology: the Federsee region in south-western Germany (Herbig 2002). Finally, an interesting comparative study between the eastern and western lacustrine areas of Switzerland has been initiated by Karg and Märkle (2002). This chapter will discuss the importance of the results obtained from the above-mentioned sites.

Until today, the archaeobotany of lake-dwellings – on-site-investigation – has concentrated on macrofossils such as seeds or cereal chaff. The results from these remains mainly indicate the foodstuffs and the environment utilized by people and livestock in the past. Therefore, in the following text we concentrate mainly on food plants and their development during the lake-dwelling era.

Results: food plants

The staple food: cereals

Cereals played a crucial role in nutrition. This has been shown by calculating the calories possibly contributed by different foodstuffs, based on the data obtained from a Neolithic Pfyn Culture site (around 3700 cal. BC) in Zurich (Gross *et al.* 1990) and the Late Bronze Age layer at Zug-Sumpf (Jacomet and Karg 1996: 258). The calories obtained from cereals must have amounted to around 50 per cent of the total calorie requirements. Therefore, it is not surprising that cereal remains are found in large quantities at most of the sites investigated. However, there are some rare exceptions such as two Neolithic sites dated around 2900 cal. BC in the Federsee region in south-western Germany. These perhaps are interpretable as specialized outposts of the main villages, used for flax growing (Herbig 2002: 49).

The cereals are found in burnt layers as carbonised ears (Figure 11.3), spikelets, grains and chaff, which became charred when settlements burnt down. A good example of such a situation is the Neolithic settlement layer of Hornstaad-Hörnle 1A at Lake Constance where large numbers of carbonized ears were found (site dating around 3900 cal. BC; Maier 2001). Here, a whole year's harvest was burnt. There was also good preservation of ears and panicles (the latter of millet) at the Late Bronze Age site of Zug-Sumpf (Jacomet and Karg 1996). Such finds of ears, especially from Neolithic times, are very exceptional and allow a much more detailed morphological investigation than is the case when only single grains or fragmented chaff remains are found (see for example Maier 1996). It was a re-examination of such ear remains in the 1980s that identified the fact

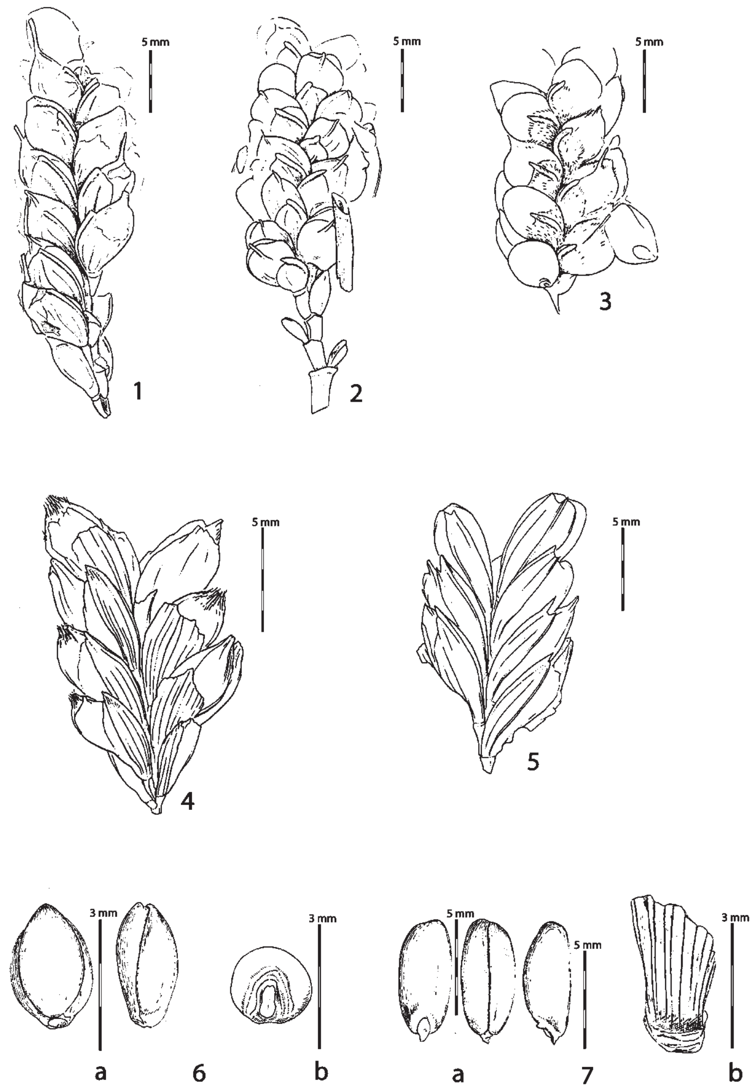

Figure 11.3 Some of the most important cereals of the Neolithic and Bronze Age lake-dwellings. 1–5 Carbonized cereal ears (mostly fragments): 1–3 different varieties of tetraploid naked wheat (*Triticum durum* Desf./*turgidum* L.; Zürich, Kleiner Hafner, Ältere Cortaillod Kultur (Neolithic), 4000–3800 cal. BC); 4 two-grained Einkorn (*Triticum monococcum* L.); 5 Emmer (*Triticum dicoccum* Schübl.); 4 and 5 from Zug-Sumpf, Late Bronze Age, around 950 cal. BC). 6–7 new cereals in the Bronze Age: 6 broomcorn millet (*Panicum miliaceum* L.): (a) grain with glumes; (b) grain without glumes; 7 grain (a) and glumes base (b) of spelt (*Triticum spelta* L.). 6–7 were found at the site of Zürich-Mozartstrasse, layer of the early Bronze Age, around 1850 cal. BC). After Jacomet *et al*. 1989 and Jacomet and Karg 1996.

that the naked wheat grown by the lake dwellers was a tetraploid (Jacomet and Schlichtherle 1984). Before that time, naked wheat was erroneously identified as *Triticum aestivo-compactum*, which is actually a hexaploid species.

In most cases, cereal remains (grains and chaff) regularly appear in a carbonized state, although also as uncarbonized (sub-fossil) parts of the chaff and in some cases large amounts of bran can be found too. Good examples of such remains were discovered at Arbon-Bleiche 3 (3380 cal. BC) on Lake Constance (Hosch 2003), and at Horgen-Scheller (thirty-first century cal. BC) on Lake Zurich (Favre 2002). In the case of cereals in waterlogged conditions, carbonized remains and uncarbonized chaff are also preserved (Jacomet *et al*. 1989: 59). As a result, it is possible to say that on dry sites, cereals are represented in a way that reflects their true abundance, primarily because they had a good chance of getting carbonized and also because they carbonize well.

Neolithic

Between *c.* 4300 and 2400 cal. BC four important cereals were grown: the tetraploid naked wheat (*Tritcum durum* Desf./*turgidum* L.); the emmer (*Triticum dicoccum* Schübl.); the Einkorn (*Triticum monococcum* L.); and a six-rowed barley, probably mostly naked (*Hordeum vulgare* L.) (see Figure 11.4). In addition, there are also some rare indications of the presence of hexaploid naked wheat (*Triticum aestivum* L.; Schlumbaum *et al*. 1998). The role of each cereal species was not always the same during the period of the Neolithic lake-dwellings (Figure 11.4), and this can be reconstructed by the concentrations found in the different layers. Tetraploid naked wheat was very important in the whole lake-dwelling area north of the Alps, mainly during the fourth millennium cal. BC. It could be found up to the Federsee-Oberschwaben region, but was absent from areas further to the north-east. This cereal came to the area around the Alps most probably from the south-west of Europe and is an indication of close contacts with this area from the late fifth millennium cal. BC onwards, a scenario supported by finds of particular pottery types (Gross-Klee and Hochuli 2002: 87). In contrast, Emmer did not play an important role at the beginning of the lake-dwelling era until *c.* 3400 cal. BC, when it became more and more important. This increase of emmer consumption was probably influenced by communities coming from the east, as is shown by the appearance of pottery of the Baden Culture (group Boleras) at Arbon-Bleiche 3 for example (De Capitani *et al*. 2002). The first finds of wooden wheels are another sign of this increased influence from the east, and can be paralleled with the development of the Horgen Culture (Gross-Klee and Hochuli 2002: 87; Köninger *et al*. 2002). The third wheat species, Einkorn, played an important role during most of the Neolithic, but only in a few places and in certain periods, as it is shown by the site of Concise-sous-Colachoz on Lake Neuchâtel (Karg and Märkle 2002). The fourth important cereal, barley, was significant during the whole period and one cannot see large changes in its importance.

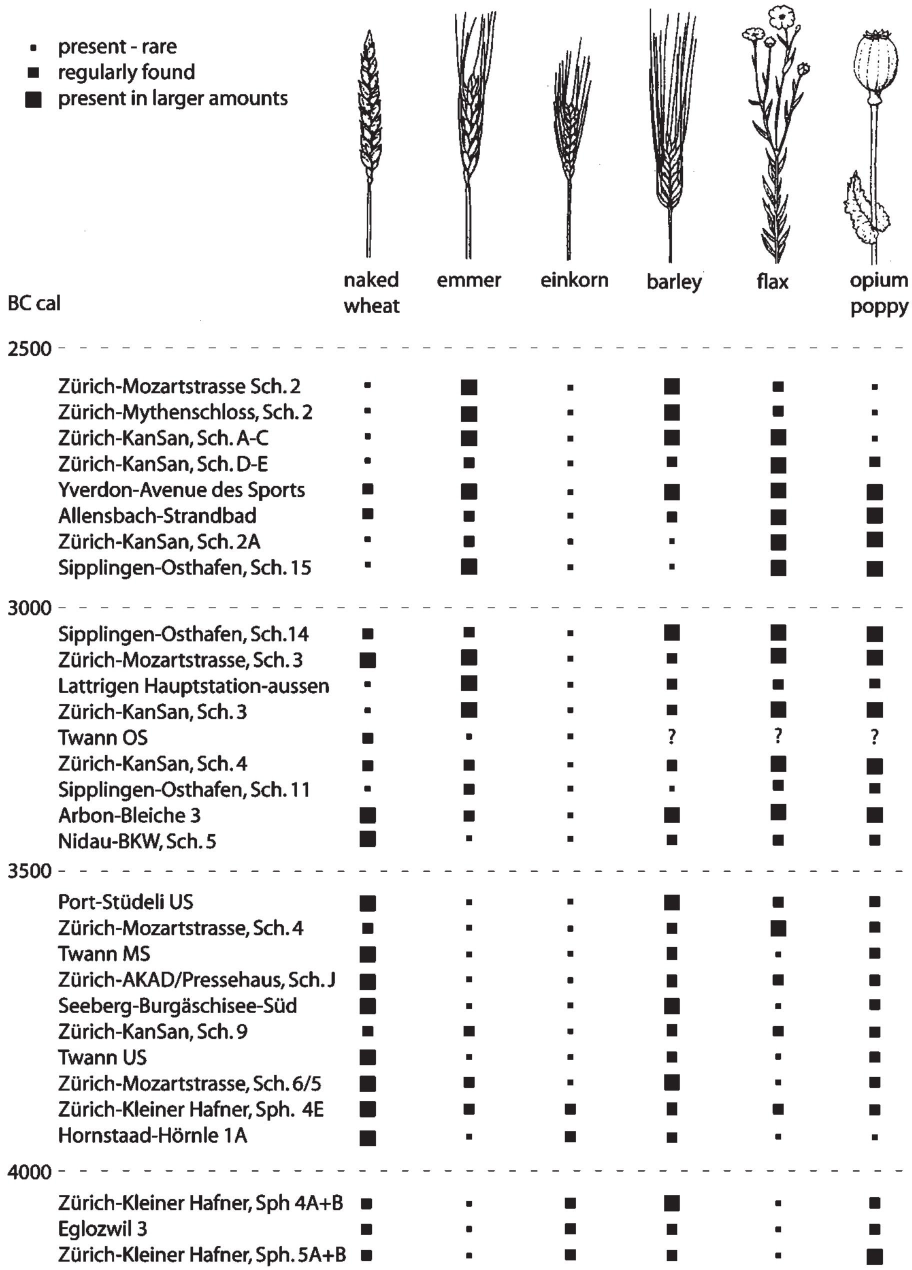

Figure 11.4 The changing importance of different cultivated plants during the Neolithic in the lake-dwelling area. After Brombacher 2000: 206.

Bronze Age

The cereal spectrum of the Bronze Age is in some ways very different to that of the Neolithic (Jacomet *et al*. 1998; Jacquat 1989). A new cereal plays an important role, spelt (*Triticum spelta* L.) (Figure 11.3). The introduction is its provenance and when it was introduced still a matter of debate. Recent results indicate that spelt was already present in the latest (not lake-dwelling) Neolithic phases, e.g. the Bell Beaker Culture (Ö. Akeret pers. comm.), and the latest DNA results show that it reappeared during the Bronze Age (this is also true for the lake-dwellings) (Blatter *et al*. 2002). Naked wheat was of only minor importance, however, it was present rather regularly (tetra- and hexaploid forms). Emmer was very important, and Einkorn was also regularly present (Figure 11.3). Storage finds from the late Bronze Age site of Zug-Sumpf (Jacomet and Karg 1996) suggest that Emmer and Einkorn may have been grown together as maslin (mixed) crops. Two important new cereals appear too, probably also from the east: the millets (*Panicum miliaceum* L. (Figure 11.3), and *Setaria italica* L.). They were still absent in the early Bronze Age layers, but present in large amounts in the late Bronze Age settlements. In the Bronze Age, the cereal spectra of sites north and south of the Alps seem very similar, although this is based upon the investigation of only one southern Alpine site, Fiavé-Carrera (Jones and Rowley-Conwy 1984).

Other cultivated plants: sources of oil, fibres, drugs and proteins

Flax and opium poppy

In the Neolithic and the Bronze Ages, flax (*Linum usitatissimum* L.) was one of the most important oil and fibre crops. Finds are mainly of seeds and capsule fragments, rarely whole capsules and parts of the stem. Most of the finds (98 per cent) are preserved in a uncarbonized state (Jacomet *et al*. 1989: 59). This means that only a very small portion of flax can be found when only dry soil is available for investigation. On the basis, mainly, of the concentration of the non-carbonised flax remains, one can observe an increasing importance of flax during the Neolithic. From around 3400 cal. BC onwards, flax remains are very common, and with the flax there is an increase in finds of spindle whorls and also loom weights. This is linked with eastern influences according to the archaeological literature (see above, increase of Emmer). The Horgen Culture – from around 3400 until 2800 cal. BC – can also be called 'the flax culture'. Alleshausen-Grundwiesen (2900 cal. BC) in the Federsee region for instance has yielded mainly flax remains and hardly any cereal (Schlichtherle and Maier 1993). Flax still maintains its importance during the Corded Ware Culture (around 2800 cal. BC), although it is not found in such large amounts as before. In the Bronze Age flax becomes less common. The reason for this could be the increasing use of woollen textiles from the Corded Ware times onwards. This aspect is supported by animal bone analyses, which show an increase in the number of sheep in this period (Hüster-Plogmann and Schibler 1997). Flax was mainly used for its fibres, but it was probably also important in food production, e.g. oil making.

Opium poppy (*Papaver somniferum* L.) is present in large amounts in the Egolzwil Culture, that is, the earliest lake-dwelling phases. It is – like tetraploid naked wheat – connected with cultural influences from the western part of the Mediterranean (Zohary and Hopf 2000). Most of the time, only the small seeds of poppy are found, and 99.5 per cent are in a uncarbonized state (Jacomet *et al*. 1989: 59). Opium poppy – like flax – does not appear very often on dry sites because its chances of carbonization were fairly low. Fragments of the seed capsules are very rare, in fact, they have only been found on two sites: Hornstaad Hörnle IA (3900 cal. BC) (Maier 2001: 72–3), and in the Cortaillod-Culture layers at Concise-sous-Colachoz (3700 cal. BC) (Märkle 2000). The reason why these parts of the plant are so rare is not clear. Maybe tit is due to the fact that they deteriorate very rapidly.

The proportion of poppy varies during the Neolithic: the largest amounts are present during the Egolzwil Culture (before 4000 cal. BC) and again – like flax – during the Horgen Culture (3400 – 2800 cal. BC). Here, the average concentrations are mostly over 2,000 seeds per litre of sediment. During the Pfyn and Cortaillod Cultures, poppy is also found in rather large amounts on the sites around Zurich. Suddenly and for no apparent reason (eastern influences?) poppy becomes rare. This change is linked with the onset of the Corded Ware Culture, in which the concentrations are only 10–20 seeds per litre of sediment. On Bronze Age sites, too, poppy seeds are never found in such large amounts as during most phases of the Neolithic. The use of opium poppy is still not clear. It can be argued that it was used as food component, a source of oil, medical treatments and also as a drug.

Pulses

During the Neolithic, pulses seemed to have played only a minor role. Pea (*Pisum sativum* L.) is only found in a limited number of sites and in low concentrations too. Pulses are mainly preserved as carbonized seeds, and therefore their distribution can be deceiving. However, the weak representation of pulses changes radically at the beginning of the Bronze Age. Large amounts of horse bean (*Vicia faba* L.) have been found in the Alpine valleys of Grisons in south-eastern Switzerland in the early Bronze Age (Jacomet *et al*. 1999). In the lake-shore area, on the other hand, large amounts of pulses are only present in Late Bronze Age sites as is shown by the large quantity of pea, horse bean and lentil (*Lens culinaris* Medik.) found at Zug-Sumpf (Jacomet and Karg 1996: 238). With the introduction of new pulses, the nutritional value of cultivated plants would be substantially increased (Jacomet and Karg 1996: 258).

Collected plants

In addition to cultivated seeds the waterlogged layers of the lake-dwellings yielded very large numbers of wild plant seeds. Wild plants played an important role during the Neolithic, but had also a great importance in the Bronze Age. Among the plants collected there are important staple foods like hazelnut (*Corylus avellana* L.), acorns (*Quercus* sp.) (Karg and Haas 1996) and wild apples (*Malus silvestris* Miller). Apples were cut into halves and dried; this is shown by many finds of such carbonized half apples in burnt layers. Some weeds were also collected as possible staple foods. Chenopods (*Chenopodium album* L.), for instance, have seeds rich in starch, and turnip (*Brassica rapa* L. s.l.) or other Brassicaceae seeds are rich in oil and proteins. Beside such staple foods, seasonally available fruits were also collected; the largest amounts come from wild strawberries (*Fragaria vesca* L.), raspberries (*Rubus idaeus* L.), blackberries (*Rubus fruticosus* agg.), sloe (*Prunus spinosa* L.) and rose-hips (*Rosa* sp.).

Agricultural activities and the environment

The reconstruction of agricultural activities is mainly based on the ecology of weeds growing on the fields, together with the cultivated plants. An overview of the newest developments is given by Jacomet and Schibler (in press; see also Brombacher and Jacomet 1997). The weeds shows a development that during the Neolithic, from small, cultivated patches in woodland clearings to a much more open landscape, although the 'core' of the Neolithic weed flora seems to be very uniform. Together with weeds in the 'classical', actualistic sense which were growing in the fields (such as, for example, *Silene cretica* L., an annual archaeophyte – a plant introduced to the area before the end of the fifteenth century AD), there were also many other open-land plants with a broad ecological distribution, mostly apophytes (plants native to the area, growing in habitats created by people). This is suggested by the range of wild plants found together with stored cultivated plants. Although this is still a matter of debate (Rösch *et al*. 2002), the weed data suggest, that in the earliest phases of the lake-dwelling Neolithic, the cleared land surfaces were used more or less continuously, without reverting back to woodland during fallow periods. Only new evaluation methods such as the use of Functional Interpretation of Archaeobotanical Surveys will shed more light on this topic (Bogaard 2002 or Jones in press). The situation remains similar in the Bronze Age (Jacomet and Karg 1996; Jacomet *et al*. 1998).

From Neolithic times onwards, the evidence of differences in weed ecology supports the suggestion that some cereals, above all the wheat, were grown as winter crops, and barley as well as other cultivated plants as summer crops (Brombacher and Jacomet 1997). The separation between summer and winter crops becomes clearer in the Bronze Age, when typical winter crops like spelt appear for the first time and the millets are typical of summer crops. The Neolithic period is also characterized by limited areas of grassland (Jacomet *et al*. 1989). One has the impression that towards the end of the Neolithic, above all in the Corded Ware phases, an increase in grassland plants proves that there were short fallow periods and the fields were grazed by livestock. A similar situation is also present during the Bronze Age.

As far we can judge from the macrofossil and pollen content of animal dung, most of the livestock which grazed in the woodland in the earlier and also later phases of the Neolithic were only kept in the settlements during the winter. Consequently we assume that there was some kind of transhumance during the summer. However, evidence for the use of milk and slaughtering dates suggest that a part of the herd was kept near the site (Rasmussen 1993; Akeret and Jacomet 1997; Akeret *et al*. 1999; Akeret and Rentzel 2001; Jacomet *et al*. in press).

If we try to estimate the amount of open land from Neolithic time onwards, pollen data suggest that during Neolithic times the amount of human impact was very small, and that only from the Late Bronze Age onwards can a more significant influence be seen (Richoz and Haas 1995). However, pollen data have to be correlated with settlement densities to be fully reliable. What seems certain is that in the hinterland, large areas of woodland still existed throughout the entire lake-dwelling phenomenon, but decreased in size towards the Late Bronze Age. (Hüster-Plogmann and Schibler 1997; Jacomet and Schibler in press).

Conclusions: future research strategies

The archaeobotanical investigation of over 100 Neolithic and Bronze Age lake-dwelling layers has brought us a remarkable understanding of the economy and the environment of later prehistoric times in central Europe. However – as already mentioned in the introduction – there are still some gaps to fill. First of all we need to investigate some areas, which have been only partially studied, such as the regions south of the Alps. A uniform methodology must also be introduced. Indeed, a proposal was made by Hosch and Jacomet (2001) in which an outline of the research history concerning sampling strategies was also given.

In general we should know more about intra-site variation and about the relations between contemporary sites in a region. Multidisciplinary investigations are still fairly limited. In order to achieve a more complete picture of the economy of the lake-dwellings, we need more analyses on the various flora remains. This concerns, above all, on-site pollen analyses (Hadorn 1994) and animal and human dung studies (Akeret *et al*. 1999), as well as new research on crusts in ceramic vessels (including micromorphology and chemistry). Wood analyses are also paramount. Small pieces of sub-fossil wood (including twigs) and charcoal allow a reconstruction of the preferences for firewood (Dufraisse 2002), as well as the areas from which firewood was gathered. Twigs can help in identifying types of animal fodder (Favre and Jacomet 1998) or the use of techniques such as basketry. In conclusion, we can certainly state that although 150 years of research have allowed us to achieve outstanding results, we are still relatively far from a representative knowledge of the daily life of our Neolithic and Bronze Age lake-dwelling ancestors.

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12

UNDERWATER ARCHAEOLOGY

Lake-dwellings below the water surface

Albert Hafner

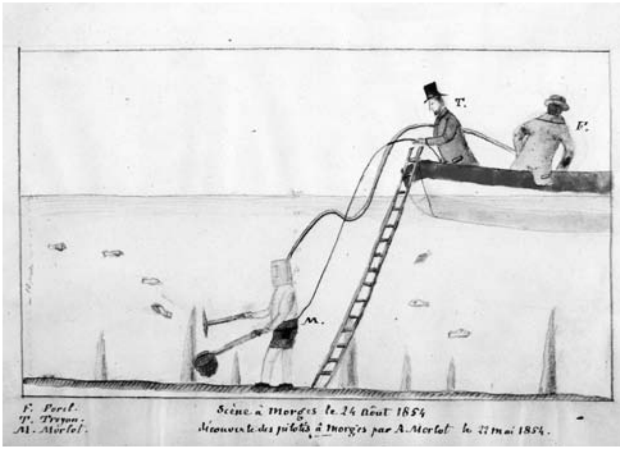
Introduction

From the diving pioneers of the nineteenth century to modern-day excavations

In 1854, the historian Ferdinand Keller announced the discovery of a prehistoric site on the Lake of Zurich and interpreted it as the remains of a settlement. Soon similar finds were made at other lakes in the Alpine region. Keller interpreted the fields of piles as the remains of platforms that had stood in open water, so he called them pile dwellings (*Pfahlbauten* in German). On 22 May of the same year, the Bernese geologist Alphonse Morlot started an expedition on the Lake of Geneva, along with Frédéric Troyon and François-Alphonse Forel (Figure 12.1, top). Their goal was a site assumed to be a lake-dwelling settlement near Morges – and in their luggage was a primitive diving bell. This was probably the first archaeological dive ever made (Speck 1981). Other researchers, such as Friedrich Schwab from Biel, also proposed building a diving apparatus, but this was never actually realized. In southern Germany, divers were used for the first time in the summer of 1873 to observe a lake-dwelling site in the Starnberg Lake in Bavaria (Schmid 2000).

In 1925, Paul Vouga tried a new way of working underwater in the Neuchâtel Lake in Switzerland. From a raft, he placed a sheet metal cylinder three metres high and one and a half metres in diameter into the water over a section of a prehistoric site. After pumping out the water from this caisson he was able to search the lake bottom over this delimited area. The method stems from bridge-building, and in 1929 Hans Reinerth used the same principle in Sipplingen on Lake Constance. He placed a double-walled box measuring 22×22 metres into the bay, providing a view of the ruins of a Stone Age village that was nearly 500 square metres. In a water depth of two and a half metres, this meant that the lake bottom could be worked for several months. At the time, this excavation method caused a great sensation (Reinerth 1932).

In 1937, Jean-Jacques Pittard investigated a freshly discovered field of wooden piles in Chens-La Vorze on the French side of Lake Geneva with the aid of a



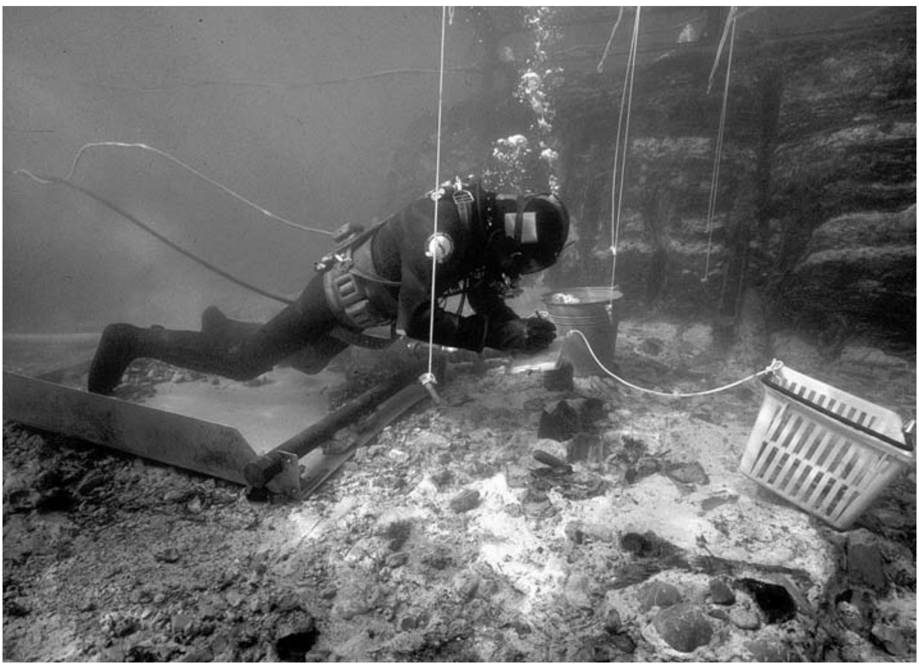


Figure 12.1 Top: the first archaeological dive took place on 22 May 1854 near Morges on the Lake of Geneva. However, the success of the 'diving archaeologist' Morlot is doubtful. His 'helmet' only functioned in an upright position so he could only rummage around blindly on the lake floor. He only managed to bring up a few stones to his friends Troyon and Forel, who were waiting in the boat – laughing (photograph: Bernisches Historisches Museum). Bottom: diver at work at Meilen-Rohrenhaab on Lake Zurich in 1974. In the background is an impressive stratigraphy of Neolithic and Bronze Age layers (photograph: Amt für Städtebau Zürich, Unterwasserarchäologie).

recently invented diving tank that had a manually operated constant air regulator. He marked over 400 piles with buoys and had them photographed from the air (Pittard 1938). In 1943, Jacques Cousteau and Emile Gagnan developed the principle of the now familiar Aqualung, which is still in use today. This invention made possible a much simpler and autonomous dive compared to the old diving helmets. For the first time, underwater exploration was not just for professional divers but could be utilized by sport divers who were fascinated by the underwater world.

In Germany, Reinerth was removed from his public duties in 1945 because of his work for the Nazi Party. However, as director of a private museum on Lake Constance, without any contact with the world of official archaeology, he made the first dives into a Bronze Age lakeside settlement in Unteruhldingen in 1951 (Reinerth 1955, 1962a, 1962b, 1963). At the beginning of the 1960s, contacts between sport divers and archaeologists began to take place in Switzerland too. In Neuchâtel, a diving group started an excavation of the Late Bronze Age settlement on Hauterive-Champréveyres. A suction pump was employed like those used in the excavation of shipwrecks. Lacking any archaeological assistance or experience, these digs were not very successful.

In 1961, a student received permission from the City of Zurich authorities to explore the known, but never excavated, site of the 'Grosser Hafner' in the Lake of Zurich. He was able to recover several well-preserved ceramic containers from a Late Bronze Age village. Stimulated by his success, a diving club also asked permission to search for lake-dwelling sites. This experience led to an intensive collaboration between the divers and the City of Zurich archaeologist, Ulrich Ruoff, which later led to the creation of a professional diving team.

Though some underwater excavations were done in the 1950s and 1960s, only the 1970s saw the first systematic expeditions by diving archaeologists. Excavations were carried out in France and Switzerland, and to a lesser degree in Austria. Raymond Laurent started the first excavation in the eastern French Alpine lakes of Annecy, Bourget and Aiguebelette in 1953 (Combier 1963). He developed the method of delineating the find areas with equilateral triangles, which is still used in France today. However, the next French underwater excavation, which was carried out near Lake Charavines, did not take place until 1972, nearly 20 years later, and continued until the beginning of the 1980s. Within the same period, the Late Neolithic settlement of Les Baigneurs and the submerged mediaeval village of Colletière were also investigated. Today, French underwater archaeology concerned with research in inland waters is focused on Lake Annecy and has also formed a permanent diving team to perform soundings and emergency digs in the various French Alpine lakes (Marguet 1995).

The first underwater excavations on the Lake of Zurich were initiated by the development and expansion of the shoreline by the City Council in 1967–9. The now-submerged island called 'Kleiner Hafner' was surveyed and various test trenches were excavated. With a diving team that was now professional, Ruoff was able to solve numerous technical problems. Many earlier underwater excavation attempts had failed because the visibility was so bad while excavating. The introduction of water-jet pipes in particular made good visibility possible. Because the excavations have to be done in the winter when the water is clear, it means that the diving is done in cold water, so the improvement of diving equipment and especially the use of dry diving suits was crucial. The methods worked out by Ruoff and his team were taken over by several diving archaeologists. These methods allow the observation and documentation of even very complex sites (Figure 12.1, bottom). Ruoff carried out most of his excavations in the Lake of Zurich and the Lake Greifen (Ruoff 1971, 1981a, 1981b, 1981c). Amongst sites of outstanding significance, it is worth mentioning that of Zurich Kleiner Hafner excavated from 1981 to 1984. During the 1990s, more than ten years were devoted to the complete excavation of a Late Bronze Age lakeside settlement in Böschen on the Greifensee Lake. Rapidly progressing erosion threatened this perfectly preserved and unusual site. Currently, the Zurich diving team is taking a leading role in the numerous diving sessions needed to make a survey of the prehistoric lakeside settlements in the waters of eastern and central Switzerland.

At the beginning of the 1980s, news that the lake-dwelling settlements on the south shore of Lake Constance were also endangered triggered the start of official archaeological diving activities. From 1981 to 1983, Josef Winiger and Albin Hasenfratz worked on a survey of the lakeside settlements (Winiger and Hasenfratz 1985). Important investigations were undertaken in Thurgau on Lake Nussbaum too, from 1988 to 1991. In this small lake, located just a few kilometres south of Lake Constance, the emergency digs provided the documentation of an impressive stratigraphy that is still threatened by erosion (Hasenfratz and Schnyder 1998).

In western Switzerland, archaeologists started to dive between 1971 and 1974. First of all, they focused on the Late Bronze Age lakeside settlements of Auvernier-Nord on Lake Neuchâtel (Arnold 1977) then, in the years 1981–4, the team of Beat Arnold started to excavate at Cortaillod-Est, where the goal was a complete excavation of the village. On a scale unknown till then, the eroded field of piles was investigated over an area of more than 7,000 square metres (Arnold 1986). In the region of the large lakes of the Alpine foothills, investigations brought to light for the first time the foundations of buildings and the complete structure of a village. After completing the excavations at Lake Constance, Winiger moved west to the Lake of Biel (Bienne) where he made a survey of the lakeside settlements between 1984 and 1987 (Winiger 1989). In 1988, a regular diving team was founded by the Canton of Bern, which has since conducted numerous rescue excavations. At Sutz-Lattrigen, about 20 Neolithic villages were investigated in the same time period and, in the years 1988 to 1990, one of them was excavated completely underwater. Investigations in the bay of Biel led to the discovery of three late Bronze Age villages in 1998 and 1999 (Hafner 1992, 2001; Hafner and Suter 2000; Hafner and Wolf 1997).

In the early 1970s, Austrian archaeologists started a promising project on the lakes of the Salzkammergut near Salzburg (Offenberger 1976), but unfortunately all activities were stopped in 1977 and have not yet been fully resumed.

In Baden-Württemberg (southern Germany), under the auspices of the cultural heritage authorities, a programme to restore underwater archaeology started in 1979. In the 1980s, on the northern shore of Lake Constance, extensive underwater archaeological investigations took place on the Neolithic and Bronze Age lakeside settlements of Sipplingen (1982–7), Bodman (1984–6) and Unteruhldingen/Hagnau (1982–9) (Kolb 1993; Köninger 1997; Schöbel 1996). Since the completion of these projects, underwater archaeology continued on several lake-dwelling settlements on Lake Constance and in various small lakes of Upper Swabia.

Methods of underwater archaeology used for excavations in lakes

Although they follow the same concept, underwater excavations used for lake-dwelling settlements are fairly different from excavations on land. In both cases, however, the main goals are efficiency and accuracy. On land, this requires the installation of a precise measurement network (grid), which, obviously can be complicated to construct in an underwater environment. Divers say that working underwater can be fairly straightforward if the site is not too deep and the area of interest limited. It becomes more problematic, however, when large areas have to be joined together into a 'complete' landscape context. A good example is the site of Sutz-Lattrigen on Lake Biel, where more than 25,000 square metres were excavated. The arduous task was carried out by marking off areas ten metres wide and up to 80 metres long.

Before starting an underwater excavation, the coordinates of the area to be excavated have to be recorded using a theodolite set on a stable base point on the shore. For this operation, the diver (usually accompanied by a boat on the surface) holds the measuring stick (with the prism outside the water) perpendicular to the point to be taken and the surveyor on land shoots the point with the electronic theodolite calculating automatically the coordinates. Throughout this operation, the surveyor communicates with the diver via an underwater communication device. The installation of a precise measurement grid is of paramount importance and the final results will definitely depend upon the level of accuracy with which this operation was carried out.

After setting up the basic measuring system, a metal structure is constructed within the excavation area that allows for detailed and swift measurement. An easily visible string is attached along the fixed points that have been set on the lake bottom. Along this string, steel pipes six metres long are mounted together and fixed to vertical supports that hold them up from the lake bed. The pipes are like those used in normal scaffolding and can be put together with the usual connections to make whatever length is needed. Two of these 'railings' form a border for the excavation area along the sides, but the front end of the area to be excavated uses mobile cross-pipes which can be moved forward a metre at a time as the dig progresses. The divers work from the sides towards the middle and when they are done excavating one area, they move the pipes forward, thus opening a new area for excavation. All the metal pipes have markings one metre apart to allow the exact placement of the cross-pipes. The fixed points placed at regular distances allow the pipe construction to be checked. The construction can be arranged horizontally and allows for fast and simple level measurements. Ultimately, any underwater excavation should be geared towards making the work of the divers as easy as possible.

Professional underwater archaeology also requires a functioning infrastructure. This usually consists of a diving base which has several functions. The main task of this diving base is to provide the air supply for the divers. A compressor compresses air which is then transported directly to the divers by compression hoses or is put into conventional diving tanks. Apart from that requirement, a warm changing room and an office for equipment and accessories are also needed. A stable boat is indispensable for working on the surface of the water and should be equipped with a motor as well. If long distances need to be covered or heavy loads need to be transported regularly, then an appropriate power motor is required. For prospecting, inflatable rubber dinghies are quite suitable, whereas longer projects require a real boat with a hard shell. A stable fixed diving platform is also a requirement. A raft can be used as a temporary solution but this has the disadvantage of turning and tossing with the wind. The platform should be stable enough for a boat to anchor to it and it should be equipped with a ladder for the diver to enter and exit the water (Figure 12.2, top). For diving security, fixing a diving flag and cordoning off the water surface to other boats is obligatory.

The personal equipment of the diver varies according to the season in which the work takes place. Because the water in the lakes is particularly clear in winter, a good deal of the diving takes place during the cold season. Dives of at least three hours require good warm insulation which is only offered by dry diving suits. Full facial masks are the best for professional purposes. Life jackets increase security while diving and nowadays comfortable, easy-to-use jackets where the lead pocket weights are pushed in from the side are available. Flippers are not used because a stable position is an advantage on the lake bottom and the diving suit usually has built-in work boots. The diver keeps his grease pencils, plumb lines, folding rule, trowels and nails in a toolbox. For sawing the wood samples underwater, a simple tree saw is usually sufficient. The wood samples and finds are transported from the dig to the laboratory in plastic shopping baskets.

In many cases, the divers carry a limited amount of air in conventional diving tanks. One obvious improvement is the use of land-based storage tanks and compression air hoses in a system that can be several hundred metres long, so a diver can be provided with a practically unlimited amount of air. A reserve tank must be taken along so that in emergencies one can uncouple from the main system and dive independently. Systems of underwater communication contribute to the security of the divers. They also allow the diver to be monitored from the base, and this, too, makes the work easier and increases efficiency.

Figure 12.2 Top: divers getting ready on the platform installed in the lake. They are about to start their three-hour work shift on the lake bottom. Bottom: underwater excavation site of one of the Neolithic lake-side settlements of Sutz-Lattrigen on the Lake of Biel. The divers draw the pile positions on Plexiglas plates and later take wood samples for the dendrochronological laboratory. Photographs: Archäologischer Dienst des Kantons Bern.

To improve visibility while working underwater, a system of pumps, fire-brigade hoses and water-jet pipes are used. These are closed tubes which take the water to the pumps and hoses, and spray the water towards the back of the dig, creating an artificial current that lets clean water flow in from the front towards the work area, while the murky water and disturbed sediment are made to flow behind the diver.

Special locations are photographed with an underwater camera and graphic documentation is done on Plexiglas plates 1 m×1 m on which the position of the posts/piles, the extent of the layers and the find locations are drawn with coloured grease pencils (Figure 12.2, bottom). Profiles too can be drawn on the Plexiglas plates. Then, back on land, the on-site drawings, which were done on a scale of 1:1, are reduced and drawn on paper and provided with a diving protocol. This primary documentation is completed right after the dive.

The achievements of underwater archaeological excavations

The origins of European prehistoric archaeology go back to the 'curiosity chambers' of the nobility and owe a lot to the thirst for knowledge of an enlightened bourgeoisie. Aside from the mythical stories of megaliths, the end of the seventeenth century is the first time that archaeological finds are mentioned. These reports mostly concern easily recognizable sites, like grave mounds or large sanctuaries. The birth of prehistoric settlement archaeology in the Alpine region, therefore, coincides largely with the discovery of the lake-dwelling settlements. The wooden parts of the buildings were perfectly preserved by anaerobic conditions, and investigations quickly suggested a very lively and clear picture. Together with ceramics and other daily utensils, it is not hard to recognize them as the remains of settlements. These remains tempted early researchers to make fantastic but scientifically unfounded reconstructions. It sounds quite paradoxical, but it is nonetheless true: the researchers of lake-dwellings knew the least about the main subject of their research – namely, the architecture of the buildings and villages.

Despite outstanding, well-preserved finds, several methodical approaches necessary for archaeological research were missing up until the 1920s. In 1926, Theophil Ischer wrote soberly: 'Strangely enough, neither the large excavations nor the many private early researches have been able to give us any information about the shapes of the huts or even a clear picture of the complete lake-side settlement in the Lake of Biel' (Ischer 1926). The first house foundations and village plans had resulted from excavations in the 1920s and 1930s on the moors of the Upper Swabian Federsee Lake where houses built exclusively at ground level were revealed. In this case, they were not true lake-dwellings as Keller had defined them according to the knowledge of his day. Even the chapter 'Pfahlbaustudien' (lake-dwelling studies) written by Emil Vogt on the 100th anniversary of lake-dwelling research could not show one single house foundation or a village plan from one of the lake excavations (Vogt 1955). In fact, it would be another 30 years before the first ones were published.

In 1981, Ulrich Ruoff reported on two Neolithic partial house foundations of about three and a half to four metres wide from the site of Utoquai/Akad in Zurich. These could be relatively dated using a sweeping middle curve of dendrochronological data (Ruoff 1981c). In the year before, Alex Furger published dates for several house foundations in the Late Neolithic site at Twann, which were also relatively dated using dendrochronology (Furger 1980). Both sites were found on the lakeshore, but what the entire villages looked like is still unclear: the buildings included in the reports were limited to a small number of units.

Shortly afterwards, Arnold published the results on the Late Bronze Age settlement of Auvernier-Nord: 24 house foundations (Arnold 1983). He continued working in Cortaillod-Est from 1981 to 1984 and he was the first to completely excavate a Late Bronze Age village at that time. From 1988 to 1990, underwater rescue excavations at Sutz-Lattrigen exposed, for the first time, the complete ground plan of a Neolithic village (Hafner 1992).

Recent examples of more or less complete village plans in lakes can be quickly listed. At Lake Constance, there are the extensive finds of Hornstaad and Arbon-Bleiche for the Neolithic era. In central Switzerland, taking only the Lake of Zurich, the Greifensee Lake and the Lake of Zug into consideration, large Neolithic and Bronze Age village foundations are limited to the excavations at Mozartstrasse, Pressehaus and Akad in Zurich; at Böschen on Lake Greifen and at Zug-Sumpf on Lake Zug. From western Switzerland there are the comprehensively documented Neolithic settlements of Nidau-BKW and Sutz-Lattrigen from the Lake of Biel. From Lake Neuchâtel, we know of the Neolithic and Bronze Age settlements of Hauterive-Champréveyres, Cortaillod-Est and Auvernier-Nord. In France, there are various sites on Lakes Charavines, Chalain and Clairvaux.

Needless to say, these comprehensive village plans were made possible by the extensive interplay of archaeology and dendrochronology. Many of the settlement plans that are available today could only have been discovered and researched by means of underwater archaeology. Two examples of underwater excavation projects undertaken recently will illustrate the quality of the results that can be achieved.

Böschen, Greifensee, Canton Zurich

Lake Greifen is one of the smallest central Swiss lakes and it is situated some 8 km east of Zurich. The rescue excavation of 1984–95 was one of the largest operations that has ever been done so far in European inland waters (Ruoff 1998). The Late Bronze Age village was built between 1047 and 1046 BC and it was most probably deserted a decade later after a catastrophic fire. It was researched over an area of about 5,000 square metres and completed after over 11,000 underwater working hours. The level of preservation of the foundations of 24 houses was remarkable. Some of the houses still had some of their central support structure with up to four layers of tree trunks.

In the inner part of the settlement, 12 large buildings (10×4 m) have a square central construction that is surrounded by piles, each with a stabilizing base-plate to keep them from sinking (Figure 12.3). These together formed the

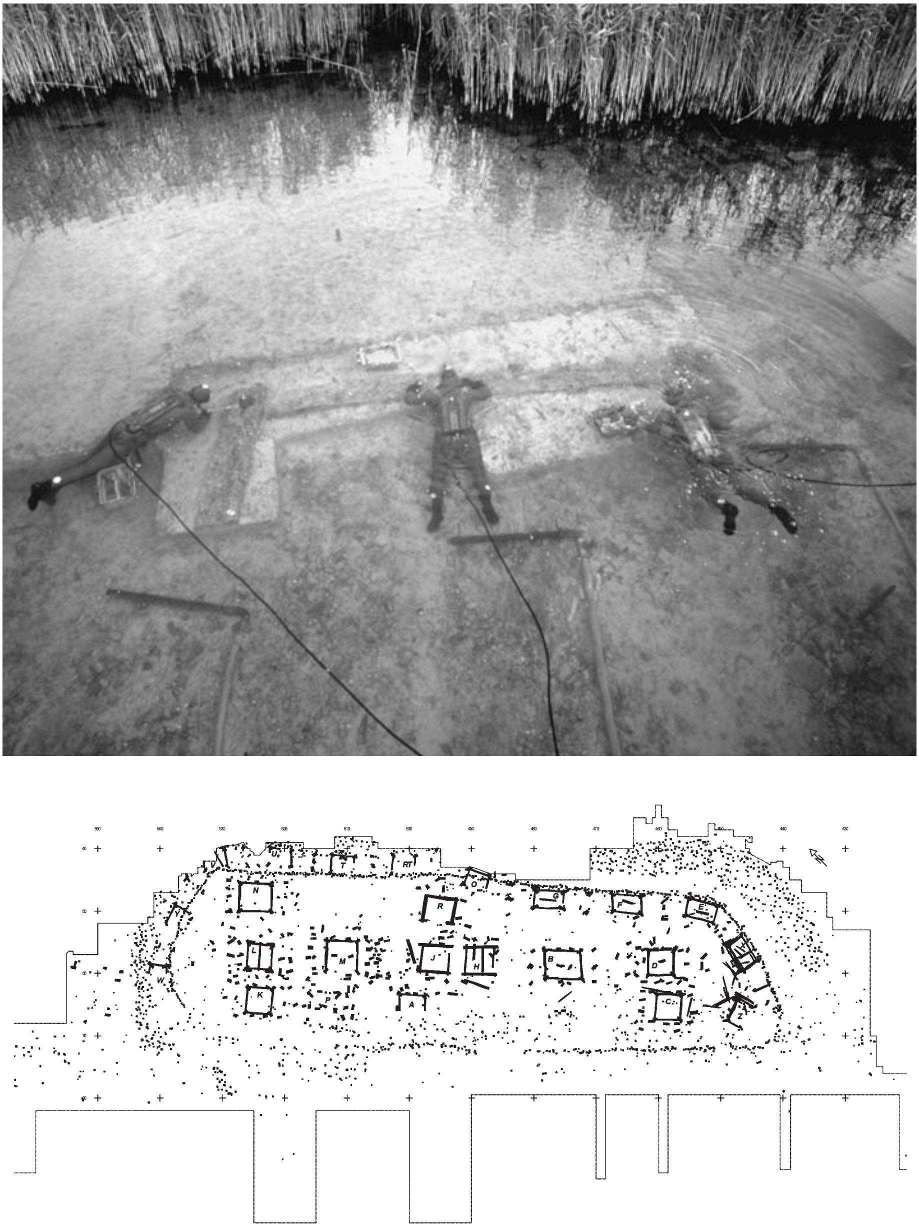


Figure 12.3 Underwater archaeological excavations at Böschen on the Greifensee Lake. Top: A team of divers at work in shallow water. Bottom: The Late Bronze Age lake-side settlement built between 1047–1046 BC is one of the few completely excavated villages. There are various indications that show that the houses were erected in the water with raised construction. Photograph: Amt für Städtebau Zürich, Unterwasserarchäologie.

supports for the platform of the house. Land-side of these houses, there are another 12 buildings in a flat half-arc that are significantly smaller (4.5 x 2.5 m). They were all built using a block construction technique, like a log cabin. The central buildings can probably be interpreted as domestic buildings, the smaller ones as storage. Finding the surrounding palisade showed that the perimeter of the entire settlement had been located.

Also of architectural significance is the almost 10-metre wide strip running along the land-side of the village with implanted, angled hazel staffs which seems

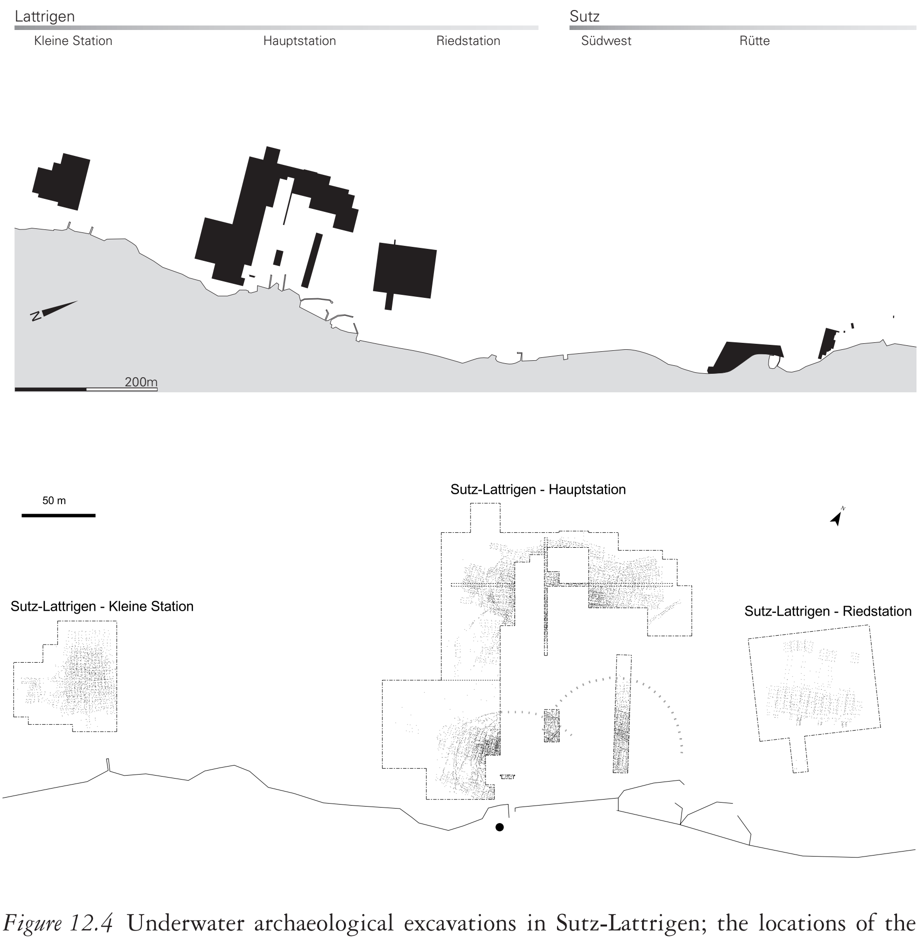
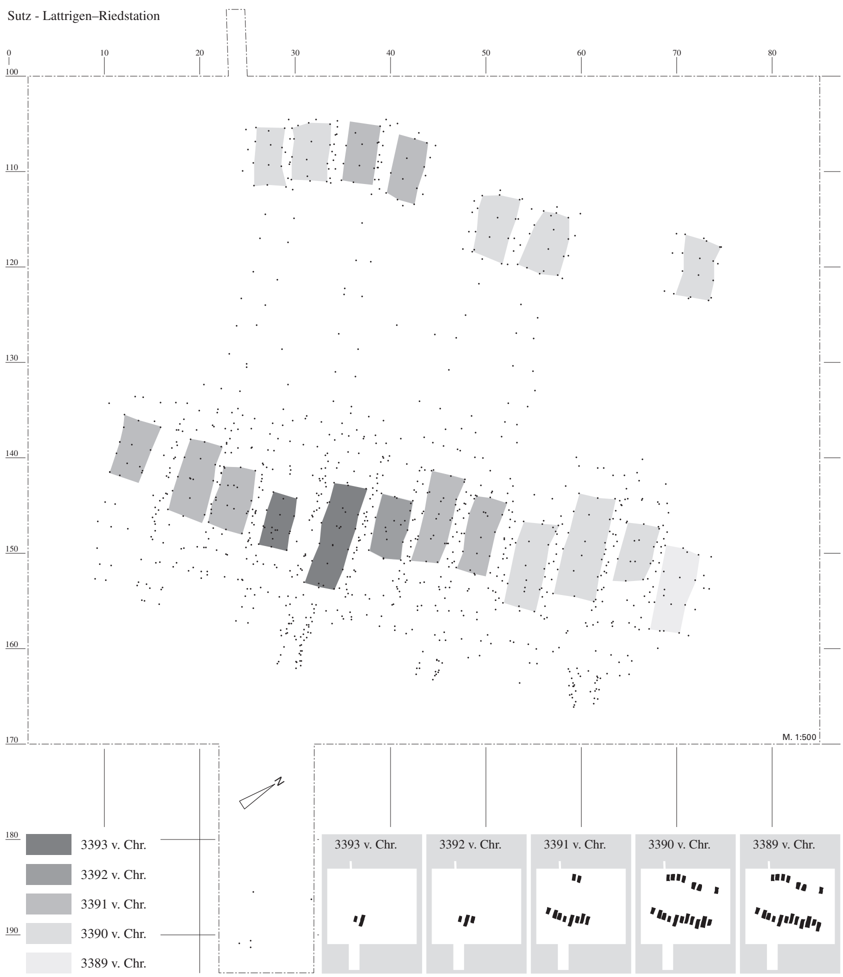


Figure 12.4 Underwater archaeological excavations in Sutz-Lattrigen; the locations of the various excavations. Above: Excavations at the Lattrigen 'Hauptstation', 'Riedstation' and 'Kleine Station'. Between 1988 and 2004, more than 25,000 square metres of lake bed were systematically investigated. Each point on the plan corresponds to a wooden pile in the lake. In total, over 15,000 piles were mapped and tested. The dendrochronological examinations led to the reconstruction of about 20 villages built between 3840 and 2688 BC. Opposite: The

to be an approach barrier. A similar construction can be found in the Nidau-Neue Station on the Lake of Biel and can also be interpreted as a defence barrier.

Sutz-Lattrigen, Canton Bern

The lake-side settlements of Sutz-Lattrigen are located on the south shore of the Lake of Biel. They have been recognized as such since the first lake-dwelling reports of Ferdinand Keller in 1854. Because of the water level regulation of



completely excavated village 'Riedstation' was occupied between 3393 and 3389 BC. It probably only existed for six years, because the dendrochronological record terminates in the year 3388 BC. Figures: Archäologischer Dienst des Kantons Bern.

lakes and rivers in the Jura region, the level of Lake Biel was about two metres lower in the 1870s, and parts of the site were easy to access. Today, these interventions in the natural water regulation have brought about serious problems for the lake-side settlements of the three interconnected lakes of Biel, Neuchâtel and Murten. A large part of the settlement area which was originally available has been eroded and only some sets of piles remain. This erosion not only affects organic materials, but also the more durable artefacts like ceramics, stone or flints.

The rescue excavations in the settlements of Sutz-Lattrigen began in 1988 (Figure 12.4). A total of over 25,000 square metres of the lake bottom was systematically documented and the find of over 15,000 wooden pilings allowed the reconstruction of about 20 Neolithic villages that existed between 3840 and 2688 BC. The oldest evidence of settlement in the bay of Lattrigen is wood pilings that were dated to about 3840 BC. Since the research is still ongoing, the structure of this settlement (the 'Innere Hauptstation') as well as the other village, 200 years younger (3640 BC) cannot be fully understood. What begins to emerge, however, is that several villages shifted to the south-west part of the bay in intervals of about 15 years, with younger building phases occurring in 3630, 3615 and 3595 BC. The next youngest settlement, which existed between 3582 and 3566 BC, offers a clearer picture. It includes about 40 buildings, of which 20 are within the excavation area. All the houses are clusered together, except one that was built 20 metres away from the others The buildings all stand with their roof-ridge at right angles to the shore. Inside the excavation area, a group of eight houses surrounded by a palisade appeared first. In the space of a few years, the village had expanded twice, each time with four new houses. The last three buildings were erected in 3568 BC and in 3566 BC.

After a break in the settlement record of about 170 years, a new village was founded. The settlement is now called the 'Riedstation' and it lies about 200 metres north-east of the Lattrigen 'Innere Hauptstation' (Hafner and Suter 2000). The village ground plan and the building history of this settlement is one of the best examples of Neolithic village architecture (Figure 12.4). Starting in 3393 BC, 19 buildings were erected within five years. The village itself was probably deserted again shortly after 3388 BC. Once again the houses stand with their roof-ridges at right angles to the shore. The ground structures of the two Neolithic settlements 'Riedstation' and 'Innere Hauptstation' are similar. In both of these villages, next to a thick row or a double row of large buildings between 8 and 12 metres long and about four metres wide, there are groups of clearly smaller houses. These could be interpreted as storage buildings.

Following another settlement occupation hiatus of about 180 years, during which the lake level was higher than today, a new Late Neolithic settlement was built and occupied continuously for more than 100 years. It is not totally clear whether the little village of 'Kleine Station' (dendrochronologically dated at about 3110 BC) was a short-term settlement shift or simply additional houses. In any case, the settlement of the thirty-first century (3040/3015 BC) lies once again in the area of the 'Äussere Hauptstation' but it now shows a completely different plan: the buildings are turned 90 degrees and are orientated parallel to the shoreline. In addition, after 3200 BC the buildings are organized in rows with alleys in between. These settlements were also larger and occupied for longer periods.

The earliest settlements of the third millennium BC lie about 1 km downstream from the previous settlements as documented in the 1989–93 'Sutz Südwest Station' report. The tree-felling dates lie between 2918 and 2895 BC (Suter and Francuz 1994). The next settlement appears again in the area of the 'Kleine Station' of Lattrigen. To date, the known dendrochronological dates place the settlement between 2845 BC and 2785 and reached as late as 2754 BC. Starting in 2763 BC, the dendrochronological dates show the settlement moved about 500 m downstream to the Sutz 'Rütte Station'. Here a minimum of two other villages were built up to 2688 BC. After a fire in 2704 BC, one village was immediately rebuilt, and these roof-ridges were also turned 90 degrees (Hafner 2002). Thousands of dendrochronological dates (precise to the year) and the evaluation of the archaeological materials recovered from the lake-side settlements of Sutz-Lattrigen mean this site will offer us many diverse perspectives on almost 1,200 years of architectural and cultural history.

Translated by: Beverly Zumbühl.

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13

WETLAND ARCHAEOLOGY AND COMPUTERS

Gary Lock

Introduction

Computers have become fundamental to much of the practice of archaeology. In a recent survey I have argued that computerization is not an achievable state but rather a process of constantly developing methods and applications (Lock 2003). For the discipline of archaeology this process is generally well established in the areas of site discovery, survey, excavation, post-excavation, cultural resource management, museums and education. Many of the interests of wetland archaeology will be enmeshed within these wider concerns and developments. This chapter, however, will highlight some of the distinctive concerns of computer usage in wetland archaeology, concentrating on the areas of discovery and management of wetland sites and their analysis and modelling. Of significant importance is the use of spatial technologies, especially various remote sensing techniques and their integration within a Geographical Information System (GIS).

Discovery and management

The special character and sensitivities of wetlands have given rise to a series of international and national agreements and conventions for their protection and management. It is widely recognized that many wetlands throughout the world are under severe threat; for example, satellite imagery has recently documented the devastation of the Mesopotamian marshlands of the Tigris-Euphrates area in Iraq and Iran since the 1970s (UNEP 2001). Through insensitive damming and drainage these ancient marshlands have been reduced from *c*. 20,000 to around 2,000 square kilometres, producing sterile salt-encrusted desert. This has forced one-fifth of the estimated half-million indigenous Marsh Arabs to abandon their traditional homeland which stretches back 5,000 years to Babylonian times, and end up in refugee camps. Not least amongst the international agreements attempting to halt such destruction is the Convention on Wetlands (known as the Ramsar Convention after its place of origin in Iran in 1971),[1] which had 123 national signatories by the end of the year 2000. Parties to Ramsar are committed to the sustainable use of their wetlands, to paying detailed attention to their designation and management and to international co-operation to meet these ends (Davies (ed.) 1993). The widespread dissemination of good practice is central to Ramsar's mission and this includes the use of GIS technology as the means of managing the diverse types of spatial and attribute data relevant to the understanding and monitoring of wetlands whether or not archaeology is involved.

Various documents are available through the Ramsar website that encourage GIS usage. Palminteri *et al*. (1999), for example, emphasize the importance of mapped data for different audiences with examples of simple analyses based on overlay and buffering operations. By incorporating satellite imagery and fieldwork data located through a Global Positioning System (GPS), they demonstrate the analytical and modelling power of GIS through the examples of plant species distributions, the seasonality of animal and bird movements and coastal and inland water level changes.

Contracting parties to Ramsar also sign up to the establishment of a comprehensive national inventory of wetlands. This is vital to the identification, management and preservation of wetland resources, and detailed guidelines are available in the form of a Framework for Wetland Inventory.[2] Again, it is GIS-based and includes protocols for the collection, storage, display and analysis of data. Remote sensing data is extremely important in this work and the Framework provides a listing of available data sources including satellite data such as IKONIS, Landsat and SPOT, and airborne data including HyMap and CASI, together with technical information on resolution, spectral bands and reliability. It also includes guidelines for determining the most appropriate remotely sensed data for wetland inventory and how those digital data fit into a structured framework for planning and operationalizing a GIS-based wetland inventory. Scale, and change of scale, are recognized as fundamental issues in the design and implementation of any such system and suggestions are made for suitable scales of data and analysis within a hierarchical approach which moves from continental, to regional and to aggregates of individual sites. Scale is an issue which I shall return to, and one that offers a challenge which GIS technology is well equipped to match (Lock and Molyneaux forthcoming). Metadata is another 'meta-issue' that runs through modern ICT applications (Wise and Miller 1997), especially in areas where it is beneficial for large databases to be able to communicate with each other, to be interoperable. The Framework provides a recommended standard metadata record for the documentation of wetland inventories so that as these data sources become available over the Internet they have the potential of all being searched from a single portal. This offers a future of integrated online resource similar to that under development for the Historic Environment, HEIRPORT.[3]

It is not surprising that the discovery and management of wetland archaeology is, and should be, correlated with and integrated into these wider developments and concerns of wetlands. There are, however, some tensions. In a survey of Ramsar sites in England, Bull and Coles (2001) show 157 British wetlands on the list since it came into force in England in 1976, totalling 747,000 ha. A series of systematic archaeological surveys of wetlands have identified the high levels of archaeological sites within these areas, although what is apparent is that the potential existence of archaeology is not always recognized in management plans. The management of wetlands has tended to be focused on aspects of nature conservation and has only fairly recently expanded to incorporate archaeology. It is often not until the archaeology is recognized that it becomes a management issue, so that in areas where it is not recognized it is preservation by default rather than by design. Whereas nature conservation can be seen, measured and monitored, archaeological remains are rarely so obvious and, where they are known, often require special techniques for preservation. Another difference is that once archaeological remains are damaged, particularly through drying-out, they cannot be restored, unlike flora and fauna, which often can. While these differences are somewhat obvious, it is crucial that they are recognized by wetland managers and integrated into management plans. This is a theme expanded on by Coles (EAC 2001) in his call for a European strategy for the heritage management of wetlands and for existing recommendations to be encoded in European policy. Marsden (2001) provides a useful overview of international, European and national (UK) legislation intended to designate and protect the heritage value of wetlands, although his conclusions reinforce the tensions already outlined above. He suggests a lack of integration and co-ordination between provisions and the contrasting purposes and aims of wetlands and archaeological legislation. Part of the problem here is one of scale, for as Marsden points out, wetlands legislation, and by implication its management focus, is based on an area approach whereas archaeological legislation is traditionally site-specific.

This difference is highlighted through the processes of discovery. Whereas remote sensing is successful for wetlands in general, the finer scale of archaeological remains requires other techniques based on ground survey. As Coles and Coles (1996) have eloquently suggested, we are dealing with the 'disappearance of the invisible' and the only way that visibility is acceptably achieved is through systematic survey of large areas of wetland. As with dry land archaeology, systematic survey is the ideal for establishing area coverages of known archaeology rather than relying on *ad hoc* reactions to rescue situations. In England, following on from the pioneering work of Bulleid and Gray at Glastonbury, there have been a series of wetland archaeological surveys which have established a proven methodology which is now computer-based.

Two early projects established the potential of detailed survey: initially the Somerset Levels Project that started in 1973 and then the Fenlands Project which from 1981 onwards saw the surface survey of 60 per cent of the wetlands in that area, some 360,000 ha. This raised the number of known wetland archaeological sites from 450 to 2,500, with some being subsequently excavated. English Heritage have been instrumental in these developments through funding a series of large-scale surveys including the North West Wetlands Survey (NWWS) which is a good illustration of the fundamental role of IT. The NWWS started in 1987 and covered seven counties with the aim of survey and management based on the archaeological and palaeo-environmental records. At an early stage in this work the importance of satellite imagery and GIS-integration of disparate data sources was established. A pilot-study showed how the integration of aerial photographs and Landsat images could be used to identify and classify different types of wetland over large areas (Cox 1992). The images themselves together with interpretative overlay drawings of areas of different sorts of wetland and estimated depths, were managed and analysed within a GIS working at the scale of 1:10,000 map sheets (Middleton and Winstanley (1993). The results of this project have been published as a series of county volumes, Cheshire for example (Leah *et al.* 1997), which demonstrates the methodology and philosophy in more detail. Here GIS underlies the work and has three major uses: first the management and storage of large quantities of diverse data including raster images (including aerial photographs, satellite images and historic maps), vector drawings (for example interpretative overlays, background map data) and spatially registered attribute data (such as surface survey counts and palaeo-ecological survey results from borehole and auger surveys). Second data manipulation that would not otherwise be possible, based on the integration of spatial data layers and associated attribute data enabling modelling of the wetlands in response to differing conditions, water levels and drainage strategies. Finally the GIS is capable of providing publication-quality maps as well as incorporating the project's electronic archive for text and graphics.

Such an integrated approach to the archaeological survey of wetlands is not new nor entirely dependent on computer technology as Taylor *et al.* (1994) have demonstrated. In this small-scale case-study of a site in Lancashire they successfully integrated stratigraphical analysis through borehole information, palynological analysis from coring, and geophysical survey experimenting with varieties of magnetic susceptibility. The result was an information-rich three-dimensional model of the peat surrounding a small lake with archaeological and palaeoenvironmental reconstruction of the last 5,000 years. Although GIS was not used in this study the approach and the data are ideally suited to this technology and suggest an enhancement to existing studies of sub-surface deposit modelling such as those based on the deep stratigraphy and borehole data of York (Miller 1996). Further potential for the integration of geophysical and other non-destructive data, this time including the planning of underwater wooden features, is shown by Bleile *et al.* (2002) working in the large lake of Plauer See in Germany. Through GIS integration, the raster geophysical results are combined with the detailed vector drawings of the underwater wood and visualized on the 3D topography of the lake bottom. A different approach to site discovery and recording, but one equally dependent on computer technology, is the high resolution GPS (Global Positioning System) and GIS survey presented by Chapman and Van de Noort (2001). Through field trials at two sites, Sutton Common in the Humber wetlands and Meare Village East in the Somerset Levels, they have established that differential desiccation of wetland sediments produces micro-topographic signatures for buried archaeology that can be identified through systematic GPS survey. By converting the survey readings into a continuous pseudo-3D surface within GIS and exaggerating the vertical scale, they were able to discern buried archaeological features.

The applications of remotely sensed data and their integration with archaeological data of various types is a vibrant and on-going area of research within archaeology generally that holds increasing potential for wetland archaeology. Relatively old technology such as CORONA satellite images are being used in new and innovative ways such as the reconstruction of 5,000 years of settlement and irrigation history for the Murghab Delta in Turkmenistan (Cerasetti 2002). A problem with satellite imagery has traditionally been one of resolution, although new technologies such as Ikonos-2 are now offering one metre panchromatic and four-metre multi-spectral ground resolution. This offers the possibility of moving beyond satellite images being only useful for larger-scale regional maps, to detailed site-level identification, especially when combined with image-processing analyses as Pavlidis *et al.* (2002) have shown in detecting Minoan sites on Crete.

As an extension to the third point above, the electronic archive, working within a digital environment should facilitate the linking of this database to existing and larger-scale heritage management systems such as Sites and Monuments Records and the National Monuments Record. As suggested above, recent and on-going developments in this area will widen these connections with increasing online access through the Internet and the connecting of widely dispersed electronic resources. More immediately, a recent initiative has established a GIS-based system for curatorial authorities in England to assess the impact of developments in wetlands on archaeology contained within them (Van de Noort and Powlesland 2001) and integrate the process into the planning procedure. Another important development in understanding and managing the diversity of landscapes is Historic Landscape Characterization (Fairclough 1999), a GIS-based procedure for the polygon mapping of blocks of landscape and the attribution of significant descriptive information. It is apparent from these few examples of recent innovative practice that the trend is towards GIS being an integrating technology for the recording and management of wetlands and landscapes, including their archaeological component. This integration suggests a future of diverse potential for wetland heritage management and one that has multi-scalar functionality at its heart, the ability to jump scale from region to site.

Analysis and modelling

There is some overlap between discovery and management and the areas of analysis and modelling. Some of the management tools mentioned above, for example, involve the modelling of surfaces and spatial relationships to aid a better understanding of sub-surface features and conditions. An area of modelling which is of particular interest to wetland archaeology is water-level modelling which can be applied to coastlines, rivers and lakes through the simulated flooding of a Digital Terrain Model. This approach can be integrated into management strategies to model the effects of differing water sources and flow rates and to estimate the impact of drying-out, especially on known archaeological remains. Flood modelling can also be used in a more analytical and interpretive way, for example within a landscape study of site location or the simulation of past landscapes at particular periods. Elsewhere (Lock 2003: 164) I have drawn a distinction between GIS usage within Cultural Resource Management, the monitoring of landscape 'as now', and GIS as a more analytical tool, an interest in landscape 'as then'. This distinction applies to wetland archaeology equally well, although, as with dry land archaeology, there are often blurred boundaries.

The importance of modelling ancient coastlines to map past landscapes is illustrated by the Barrington Atlas of the Greek and Roman world, for example the area around the River Po delta on the north east coast of Italy (Elliott and Talbert 2002). This work shows the dramatic changes in coastline from the first millennium and how the Classical landscape was configured with settlements, roads, aqueducts and centuriated land divisions. Here though, GIS technology is used only for integrated mapping using data from geological and archaeological fieldwork together with modern pilotage charts, rather than as a flood modelling tool. This more analytical approach is illustrated through the work of Nunez *et al*. (1997) who use GIS techniques to approximate the evolution of the shoreline, landscape and settlement during prehistoric times in the Åland islands situated between mainland Finland and Sweden. This is an area of considerable isostatic uplift since the melting of the icecap at the end of the last glacial period, and this work models that uplift through time and relates the known archaeology to the changing coastlines of the islands. The technique involves a series of 'timescapes' or pseudo 3-dimensional period maps that show the correlation between elevation and changing occupation through the Neolithic, Bronze and Iron Ages as the land rose and settlements were established on the newly exposed shores. A similar approach for an area of south-west Finland is reported by Uotila *et al*. (2003), where, again, isostatic uplift has been modelled using GIS. The emphasis here is on visualizing the area at different times to establish possible sailing routes around the coastline and the socio-economic impact of coastline change on settlement patterns.

Hydrological modelling has also been successfully used for various aspects of lake archaeology, again mainly based on simulating changing water levels. Investigating aboriginal fish traps on Lake Condah in Victoria, Australia, van Waarden and Wilson (1994) modelled the rising and falling water levels of the lake and how stone traps and holding pools worked in relation to these changing water levels. Using detailed survey data and aerial photography they produced an accurate Digital Elevation Model of the lake edge which when flooded showed how the traps and pools filled with water, guided and caught the fish. Using archaeological and geological data, Ceccarelli and Niccolucci (2003) have taken a similar approach to modelling the silting-up of the ancient Lake Prile on the coast of southern Tuscany, Italy. The result is a series of 'time-shots' showing the changing lake shoreline in the Palaeolithic, Bronze Age, Etruscan and Roman periods with the known archaeology for each. Moving north to the Alpine region, Menotti (1999) uses CAD and GIS technologies to explore the abandonment of the Early Bronze Age settlement of Bodman-Schachen 1 on Lake Constance, Germany. Using pollen and sedimentological data as well as the archaeological settlement evidence, through lake level simulations he suggests climatic deterioration and rising water levels as the reason for the prehistoric populations leaving the lakeside and moving inland.

Interesting and varied work has been carried out using spatial technologies to study aspects of river behaviour and its impact on different aspects of archaeology. In the north-west Mississippi area of Tennessee, USA, Johnson (1996) has investigated the usefulness of Landsat imagery for the characterization and location of archaeological sites. This area has seen dramatic changes of landform throughout the Holocene which has resulted in features, soil types and vegetation zones that are identifiable on the satellite imagery. Image Processing software was used to classify the satellite image TM spectral data into zones of land use and although the results were too general to be useful in settlement pattern modelling, it is useful background data for archaeological surveying. More meaningful results were achieved through the spatial analysis of the mapped soil types and elevation data for the area, resulting in the conclusion that well-drained soils on relatively high locations near to oxbow lakes were preferred.

A very detailed and rich interpretation of the behaviour of rivers and their impact on archaeology within a wetland area is offered by Budja and Mlekuž (2001). This is a study of the Mesolithic, Neolithic and Eneolithic archaeology of the Ljubljana Moor in Slovenia where lake-dwellings and lithic scatter data have been incorporated into sophisticated GIS modelling and simulation. The area floods annually, with occasional large catastrophic flood events, and as a result has a complex alluvial history of stream and river movement and change. GIS modelling has thrown light on the importance of levee formation, the migration of meanders and their isolation through neck cut-off and avulsion which results in ribbon lakes and palaeochannels. The long-term effects of floodplain dynamics are modelled and presented through animations,[4] and compared to the known locations of the pile dwellings and scatters.

One of the important aspects of this work is that it attempts to integrate GIS approaches with recent more widely applicable landscape theory. This is building on the approach of Gillings (1995, 1997) who has used the Upper Tisza Project (north-east Hungary) as the basis for re-formulating GIS and landscape archaeology. One of the major debates within GIS applications in archaeology generally has concerned whether we can use the technology to move beyond deterministic, functionalist interpretations of landscape and incorporate the humanistic aspects of landscape interpretation now widely adopted (Lock 2003: chapter 5). Gillings attempts this through notions of phenomenology and reducing the difference between culture and nature to encourage experiential understandings of what it was like to live on a floodplain, what opportunities that would offer at different times of the year together with what limitations. This suggests a more reflexive use of GIS technology and also a more critical and theoretically aware use rather than simplistic deterministic modelling. A now well-established, and often over-used, technique within this whole argument in favour of humanizsed approaches is visibility studies through the use of viewshed analysis. Within a wetlands context this has been illustrated by Chapman (2000) through his analysis of the Iron Age site at Sutton Common in northern England. Modelling is based on detailed topographic survey of the earthworks and interpolated ground water levels from data collected through 50 piezometers spaced over the whole area on a 50-metre interval grid. This established that the area between the two enclosures was flooded during their use in the Iron Age and formed the basis of a sequence of viewsheds simulating the view of someone walking through the small enclosure and approaching and entering the larger one on the other side of the flooded channel. This shifts the emphasis of the study away from sites and landscapes at the larger scale to the embodied experience of moving and seeing as the basis of understanding past places.

Conclusions

In this chapter I have attempted to show that the use of computers in wetland archaeology is, perhaps not surprisingly, following a similar trajectory to the on-going development of computer applications in archaeology more generally. It is clear that wetland archaeology demands the recognition of the importance of spatial data which is being met through the increasingly sophisticated and integrated use of GIS technology. This is becoming fundamental to the recognition of new sites and areas of heritage potential within wetlands as well as to their management and preservation. International codes and agreements which recognize the importance of GIS and its inclusive technologies such as satellite imagery are now well established in these areas.

Wetland archaeology, whether focused on coastlines, lakes or rivers, has particular interests in terms of analysis and interpretation. Again, research in these areas is becoming fundamentally GIS-based partly because of the potential in analysing complex and varied data-sets but also because of the modelling and simulation power of the technology. Water-level simulations are central to much wetlands analysis and GIS is more than capable of moving beyond simple mapping to more sophisticated visualizations and understandings of flooded terrains. As with much of archaeology, the future of wetland archaeology is virtual in the sense of increasingly working within a digital environment, from the initial capturing of data, through its management and analysis to its presentation and publication on the Internet.

Notes

1 http://www.ramsar.org/ [accessed 9 May 2003].
2 http://www.ramsar.org/key_guide_inventory_e.htm [accessed 9 May 2003].
3 http://ads.ahds.ac.uk/heirport/ [accessed 29 May 2003].
4 http://users.kiss.si/~k4ff0495/ [accessed 5 June 2003].

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Part 3

NEW PERSPECTIVES IN LAKE-SETTLEMENT RESEARCH

14

DISPLACEMENT, READAPTATION AND CULTURAL CONTINUITY

A lake-dwelling perspective

Francesco Menotti

Introduction

When we study a cultural phenomenon, we often tend to isolate and consider it from a diachronic perspective. Even within the phenomenon itself, we sometimes neglect its evolutionary aspect; where it originated, how it developed and, most importantly, its continuity within a specific time span. There are barely any phenomena which do not lack chronological homogeny. Obscure periods within a single cultural group or society are in fact quite common. This is particularly true as far as the lake-dwelling phenomenon in the Alpine region is concerned. It fact, throughout its occurrence (forty-third to seventh centuries BC), human occupation on lacustrine areas was not continuous. There were periods when the lake shores were totally abandoned, and others when they were intensively settled (Menotti 2001). The reasons why these hiatus occurred might have varied each time (cultural or environmental factors), but what is known for sure is that those communities had to change their lifestyle (sometimes drastically) in order to readapt to the new environment.

The focus of this chapter is not particularly on what triggered the abandonment, but mainly on the aftermath; what happened once the settlements were abandoned, where those groups went and how they coped with a different environment. Through a combination of anthropological theory and archaeological evidence, I hope to be able to shed some light on these hiatus and monitor the adaptation process that occurred during those 'obscure' periods (which might have involved acculturation and cultural change). As a final goal, I will aim to reconstruct cultural continuity within those wetland groups and perhaps even understand what led them to repopulate places which their ancestors had previously abandoned.

Human adaptability as a response to variability

When we deal with human adaptability, we tend to emphasize the flexibility of human response to any environment. In studying human adaptability, it is important to include behavioural and cultural adjustments to environmental change in order to avoid barren debates over whether cultural or biological studies are the most suitable for understanding interactions between humans and their environment. The human adaptability approach should deal with specific problems faced by people of various environments rather than with a single environment as a static entity that limits human possibilities (White 1974). This approach should focus on how human populations, in interacting with each other and their environment, try to overcome different environmental variations.

Because of the incomplete availability of data, studying entire communities could be quite complicated. As a result, some scholars have chosen to deal only with specific behaviours of populations, for example human responses caused by clearly defined limiting factors (Moran 1995). Choosing a problem as one focus of research allows us to get away from the debate over a single group, population or ecosystem, and requires initially that several levels of response to the problem be considered. For instance, constant stress may be coped with by irreversible physiological change during the developmental period of a single individual or community. By contrast, temporary physiological responses facilitate the adjustment of people even after they have become fully adults. These kinds of responses are reversible. The most common forms of adjustment, however, are behavioural, social, and cultural, as these require less commitment by the physical organism (Moran 1990).

Without any doubt, the term 'adaptation' is the centre of the ecological approach. All living organisms, human and non-human, respond to the structural and functional characteristics of their environment. Adaptations are the result of exposure to physical factors in the environment, regardless of whether interaction with individuals occurs with other species, or within the same species. One type of adaptation which requires a slow adjustment to environmental variability is natural selection, whereby individuals with one type of adaptation are replaced by those with another. It is important to note though that both humans and animals have the capability for so-called maladaptation (Laland and Williams 1998). In fact, since we are capable of learning from others, and since social learning is an important mechanism for rapid adaptation to changing circumstances, it also allows for the diffusion of naturally adaptive behaviours.

Regulatory, acclimatory and developmental adjustments operate by a process known as negative feedback (Ricklefs 1973). This type of feedback seeks to maintain a stable relationship between the organism and the surroundings. On the other hand, positive feedback occurs when the system subsides. To be effective, a response to a change must be of proper scale and occur at a time and rate that is appropriate in relation to the stimulus that triggered the adjustment itself. Regulatory responses happen rapidly and reflect the physiological and behavioural flexibility of an organism. Therefore, the behaviour is a form of regulatory response that can either serve to maintain a stable relationship to the environment or facilitate adjustment to variability in that environment. Cultural ways of dressing and shelter are amongst the most common regulatory mechanisms that augment human chances of surviving and living in relative comfort in a variety of environments. Acclimatory responses take longer to be effective, because they require a change in organismic structure. Similarly, developmental change also occurs over a relatively long period, but while the acclimatory responses are reversible, the developmental ones are not (Ricklefs 1973).

When we study human adaptability, it is important to consider the ecosystem as the total situation in which adaptability takes place. Because human populations have spread over the entire planet, the context of adaptability varies a great deal. A population in a specific ecosystem adjusts to environmental conditions in specific ways that are related to both present and past conditions. When people begin adjusting to a new environment, a process of change is initiated. This process may take several generations to be completed, and the final result may be quite different from the adjustment of the original inhabitants (White 1974). This is particularly true when a variety of forms of adjustment can be borrowed from local groups. The newcomers might adopt some of the practices of the original inhabitants in order to achieve an adequate adjustment to their new habitat. Human adaptability can proceed along a variety of paths. In the absence of borrowing and diffusion of ideas, the population may be innovative and develop new forms of adjustment. If the new adjustments are not in complete harmony with previous practices and yet provide an effective solution that does not jeopardize the survival of the group, some form of compromise may appear (Lees and Bates 1990).

Researching human responses to environmental variability includes considerations of how various ecosystems are structured and functionally related. Flows of energy, matter and information form the connecting junctions between components of the ecosystem available to people (Adams 1973; Gardner and Stern 1996; Mackay 1968; Rappaport 1971). Low mean biological productivity may limit the population densities that can be supported. Groups are therefore forced to reduce activity in order to minimize caloric expenditure, which can result in population loss through famine. In contrast, human adjustments such as migratory behaviour and trade connections with more productive areas may provide the energy, matter, and information expenditures needed to allow these populations to achieve high demographic densities, engage in calorically demanding work, and prevent decimation from occurring (Rappaport 1971, 1977; Bennett 1976).

Development of theory in the study of adaptability

Before proceeding with empirical examples of human adaptability as a response to constraints, it is important to explore the historical development of theory and method within the study of human/environment interaction, in order to see how different approaches to the research were, and still are, adopted.

From the time of ancient Greece through the 1950s, ideas about the relationship between people and nature emphasized three main themes. One was the notion that the environment had a determining influence on society. Greeks and Romans believed that this influence took place through the action of climate upon the body, favouring health, and other human activities (Thomas 1925). Such a view was accepted well into the eighteenth century and moved towards the importance of geographical features and their influence on society in the nineteenth century. The second theme was that of human adaptation to environment. These views emphasized the interaction of human beings with nature. Eighteenth-century writers addressed the problem of teleology and causality in nature and proposed stages along which human society progressed (Glacken 1967). New insights to the adaptational approach were triggered by the development of evolutionary theory, which provided new theory and method that simultaneously helped explain change and continuity. This approach was essential to the emergence of modern theory of people–nature relationships. The third theme saw the environment as a limiting factor. This view, initially promoted by Malthus and subsequently by Boas (1963 [1911]), demonstrated little sensitivity about nature and favoured the human side. The Boasian approach should be understood as a reaction to the generalizations of determinists and as an effort to return scientific investigation to empirical and more unpretentious targets. It is obvious that these three themes are not totally distinct. While the first emphasizes nature and the last people, the adaptational-evolutionary approach serves as mediating model between the two extremes.

The last 50 years of research have been fairly productive for environmental approaches. Julian Steward's research, which started in the 1930s, but was not implemented until the 1950s, sought general theory, aiming to develop what we know as middle-range theory (Steward 1955). New approaches also started to develop. The cultural ecological approach for instance was helpful in reconsidering the subsistence system of hunter-gatherers, pastoralist and pre-industrial cultivators (Netting 1977). More approaches, namely ecological anthropology and ethnoecology, were then developed in the attempt to overcome these deficiencies (Frake 1962; Odum 1971; Moran 1990). New theoretical aspects of environmental research such as evolutionary ecology, historical ecology, political ecology and finally human dimensions of global environmental change were developed in the 1980s and 1990s (Crumley 1994; Sheridan 1988). These have indeed helped shape the contemporary practice of environmental anthropology and archaeology.

Prehistoric lacustrine environments in the Alpine region: uneven patterns of human occupation

A striking feature of the chronological aspect of the lake-dwelling phenomenon is its lack of homogeny in human occupation. Throughout the entire phenomenon (forty-third to seventh centuries BC), the lake shores were abandoned several times and subsequently reoccupied. This discontinuity is noted in the whole Alpine region, but it does not follow the same pattern everywhere. As a result, the prehistoric lacustrine villages' chronology in the northern Alpine region is quite different from that of the southern parts of the Alps (Menotti 2001). In some cases, as in Switzerland for example, variations can occur within limited areas even though the environmental and cultural aspects are fairly similar. Despite this pronounced regional distinction, three major hiatus can nevertheless be noted in the northern Alpine region: one in the Neolithic (thirty-fifth to thirty-fourth centuries BC) and two in the Bronze Age (twenty-fourth to twentieth and fifteenth to twelfth centuries BC). It is generally agreed that the first and the last ones were caused by environmental factors (Burga 1988, 1993; Magny 1992, 1993a, 1995a and Chapter 9), whereas the second was caused by cultural factors.

Climate and lake-level fluctuations

Long-term and seasonal lake-level fluctuations are mainly determined by climatic conditions. An increase in humidity results in an augmentation of precipitation and a consequent variation of the lake-levels (Engstrom and Wright 1984). As it has been noted by Magny (1992) though, not all lakes react in the same way to climatic oscillations. An important role is played by the so-called sensitivity of the lakes, which is mainly linked to the ratio of the catchment area to the lakes' area. In other words, the intensity of a fluctuation in lake level depends upon the natural origins of the lakes, the size and length of the lakes' inlets and outlets, and finally on the geological as well as the morphological structure of the basin area. As a result, it is possible that during the same climatic variations one lake records lesser or weaker fluctuations than another lake situated nearby (Magny 1993b, 1995b). Regardless of how the lakes were affected and the intensity of the fluctuations, archaeological evidence shows that a number of lacustrine sites (particularly those of the sixteenth century BC) were certainly abandoned following severe flooding (Gross 1987; Menotti 1999a, 1999b, 2002).

Cultural factors

Climatic influence was not the only cause that triggered the lake-dwellers' exodus from the lake shores. Cultural factors played an important role as well, in shaping the lake-dwelling chronology in the Alpine region. In fact, the longest hiatus was probably related to the Bell Beaker Culture's expansion. Whether the Early Bronze Age northern Alpine lacustrine groups were forced to leave by the 'invading' foreign culture, or if they decided to adopt the Bell Beakers' way of life is still unclear.

Another important cultural aspect of wetland human occupation in related to architectural adaptations (Pétrequin and Pétrequin 1984; Pétrequin 1991; Nicoud 1992), variations in population density (Pétrequin *et al.* 2002), and even to defensive strategies in relation to land availability, warfare and the ratio of 'alternative' settlements inland (see also Chapter 3).

Regardless of the nature of the cause which triggered the lake-shore abandonment, one aspect that is fairly clear is that those wetland groups were 'forced' to adapt to a new and drier environment after the displacement occurred. As has been pointed out above, the processes of adaptation may take various forms, using a number of cultural and ecological variables, which can produce different results. The next part of this chapter gives possible explanations regarding the cultural change undergone by some of those lacustrine groups.

Bridging the gaps: reconstructing continuity

Where did the Alpine lake-dwellers go once they abandoned the lakes, and how did they cope with the new environment? These simple and straightforward questions are indeed not easy to answer. A number of theories have been developed since the dawn of lake-dwelling research, but no precise and perfectly suitable one has yet been found. A simple but quite obvious approach to the study has been advanced by the author, who argued that, before going further inland, the lake-dwellers must have tried to occupy the nearby areas of the lakes (Menotti 2003). In researching the Middle Bronze Age hiatus, the author has considered the sites in the vicinity of the lakes (in particular those of the Lake Constance and Lake Zurich regions) that were built during the Middle Bronze Age occupational gap (fifteenth to twelfth centuries BC) (Schlichtherle 1995; Rigert 1998, 1999, 2001; Hochuli 1995; Gnepf *et al.* 1996; Dieckmann 1989, 1991; Aufdermauer and Dieckmann 1995; Fischer 1997). Once the sites were located, he then did comparative typological analyses on their material culture (mainly pottery, house structures and living floors). The results showed a connection between those sites and those of both Early and Late Bronze Age lacustrine groups. The majority of the Middle Bronze Age 'land' settlements near the lakes, but not necessarily on the lakes, was most probably constructed by former lake-dwellers after the lake-shore abandonment (Menotti 2003).

The Kreuzlingen case-studies

We know for sure that any time the lake shores were abandoned, a new pattern of occupation took place. There was a search for new land, which had to be suitable for both settlements and agriculture. So, how did the lake-dwellers move inland?

Thanks to the fortunate discovery of Kreuzlingen, excavated and researched by Erwin Rigert (1998, 1999, 2001), it has been possible to monitor one of the lake-dwelling 'inland' shifts, which occurred in the Middle Bronze Age, in a chronologically way from start to finish.

Following an archaeological survey for the construction of the motorway N7 Schwaderloh-Kreuzlingen, a number of Middle Bronze Age sites came to light between 1997 and 1999 in the Kreuzlingen area where the Rhine joint Lake Constance in Switzerland. The majority of these sites turned out to have been built between the fifteenth and twelfth centuries BC, exactly during the Middle Bronze Age lake-dwelling hiatus (Rigert 2001). Not only did typological analyses of the material cultural found (mainly pottery, house plans and living floors) reveal that those settlement were most probably built by former Early Bronze Age lake-dwellers who were 'fleeing' the lake shores, but further GIS spatial analyses were even able to monitor that inland movement (Menotti 2003). In fact, most of the settlements built at the beginning of the exodus were located closer to the 400-metre contour line (the maximum expansion of Lake Constance during the Middle Bronze Age), whereas those built later on lay further inland (Figure 14.1). When the lake level retreated again at the begin-

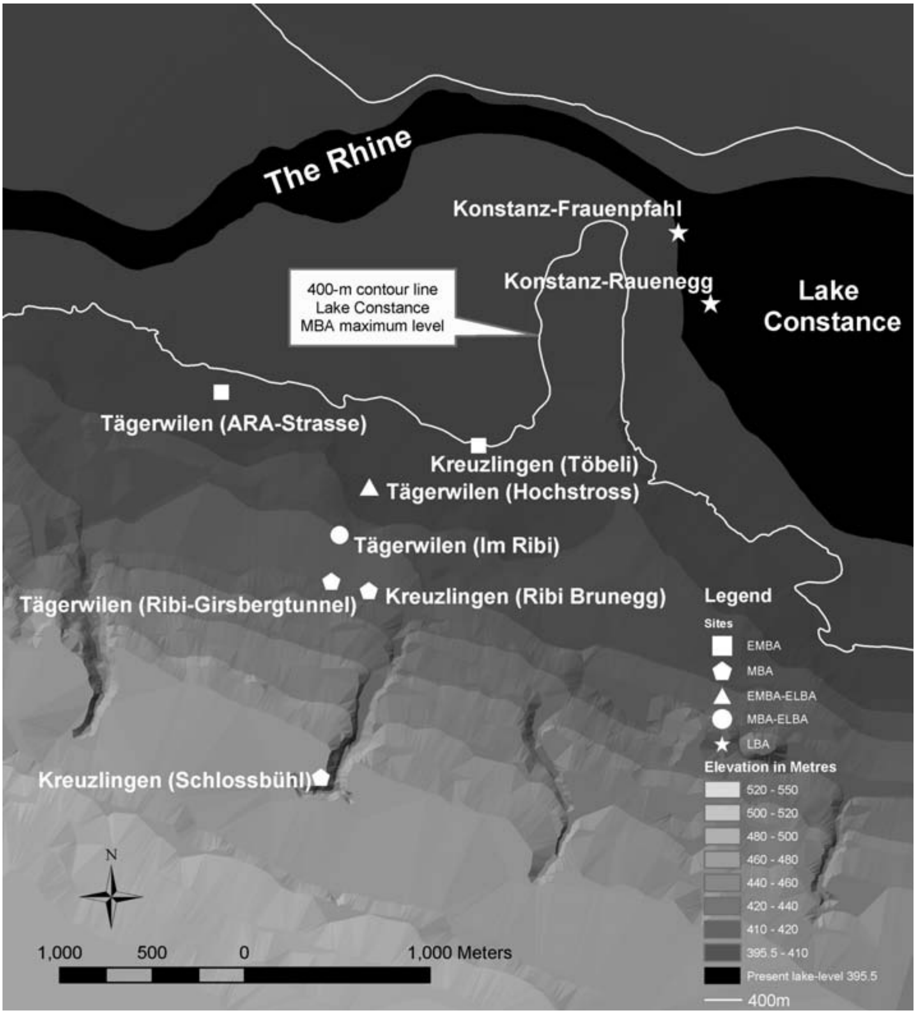

Figure 14.1 GIS applications showing the Middle Bronze Age settlement distribution in the Kreuzlingen area on Lake Constance, Switzerland. Key: EMBA=Early Middle Bronze Age; MBA=Middle Bronze Age; ELBA=Early Late Bronze Age; LBA=Late Bronze Age. After Menotti 2003.

ning of the Late Bronze Age, the former lacustrine groups started to build their villages closer to the lake shores as their Early Bronze Age ancestors used to.

Conclusions

The attraction of lakeside environments arose from two different sets of features, which could serve various economic, defensive, architectural or even transport purposes. Beyond the immediate margins of the lakes, not only were the surrounding resources different, but the terrain itself demanded a different approach to construction. The whole architectural tradition, as well as economic habits, had to be reformulated in new conditions in the event of a displacement or a migratory process.

The magnitude of the response to variability does not depend simply upon provisioning and economic activities, but extends beyond these to exert a strong influence on culture in general, shaping the society's organization and providing the conditions that give rise to social change and transformations. The strength of human culture is its flexibility in coping with recurrent but unpredictable deviations from normality. This permits a creative response, even to the massive scale of dislocation which may result from radical social or environmental change. For different reasons which can include warfare, climatic change or environmental deterioration, communities can be forced to abandon their settlements and resettle in a completely different environment. One likely outcome of this forced migration process is the radical transformation of the society and its coping mechanisms. Adaptation to a new area, for instance, may cause certain social transformations which are reflected in the society's material culture, especially if the newly settled environment is different from the previous one.

In the process of the lake-shore abandonment, some of the lacustrine societies came into contact with other groups which were already living in the lakes' surroundings, and various traditions and customs started to be adopted by different cultural groups, triggering an initial process of acculturation. The former lake-dwellers had to adapt themselves to a drier environment, and this not only changed the way the former lake-dwellers constructed their habitations, but also affected the surrounding landscape. In fact, the search for new tillable land as well as pasture land started a process of deforestation which influenced, in particular, the hilly areas around the lakes. The Alpine lake-dwellers had to modify their method of food production and consequently their economy. Even material culture underwent a process of transformation, and pottery, in particular, absorbed various characteristics from other local groups, this created new types, which nevertheless retained some old decorative patterns, thus allowing archaeologist to reconstruct cultural continuity.

The emerging pattern from recent studies of extensive Middle Bronze Age settlements on dry land in the neighbourhood of formerly densely settled lake areas throws a new light on the marked discontinuity in lakeside settlements, which is such a striking feature throughout the whole lake-dwelling phenomenon. It appears that there was a consistent and relatively widespread pattern of population displacement in the Alpine region, in which settlement shifted to new locations as a result of critical changes in the environments preferred previously, forcing a degree of economic and cultural change, as well as an accommodation to new social patterns. The study of these hiatus not only sheds some light on the hiatus *per se*, but offers fascinating examples of human adaptation, which are vital for a better understanding of the evolution of prehistoric societies from a cultural continuity perspective.

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Part 4

EXPERT VIEWS AND PUBLIC INTEREST

Finding a balance

15

LAKE-DWELLING MUSEUMS

Academic research and public information

Gunter Schöbel

Introduction

The lake-dwellings and bog settlements in wetland areas of middle Europe form one of the best 'archives' available to archaeological exploration. It is not surprising therefore that a number of scientific techniques have been successfully developed here over the past 150 years which give a deep insight not only into the settlements themselves, but also into their relationship with their surroundings (Schlichtherle 1997: 7; Furger 1998: 27; Coles and Coles 1989: 7). Given the richness of this scientific knowledge, which could be so useful for education and information, it is amazing that it has been so little discussed in public, in education (Osterwalder-Maier 1990: 173) and in museology (Sommer 2002: 14) over recent decades.

Notable exceptions were the 'lake-dwelling debate' (*Pfahlbaufrage*) (why and how people built those settlements), and the 'heritage question' (who built them). Romantic images of houses on stilts made schoolbooks more colourful and the pupils (as well as teachers) started to believe that they were the descendants of Celt, Phoenician, Slav, Helvetian and Indo-European populations which, 'once upon a time', decided to populate the picturesque Alpine lakes. Today one speaks in a more objective way about the lake-dwellers and stays within a less controversial sphere of explanation.

Despite the fascination that has always surrounded the lake-dwellings, there have been moments in history when their popularity was abused, e.g. during the nationalistic years of Germany between the two World Wars (Rückert 1998: 87). In addition to this came the 'lake-dwelling problem' (*Pfahlbauproblem*), which created bitter disputes between various scholars and made the research ideologically biased (Speck 1990). Based on new discoveries it was finally agreed that all the different theories were acceptable and research moved on.

Children's books, pictures, cartoons, school history books, films, poems and popular periodicals written by archaeologists, some with a high circulation (Keller-Tarnuzzer 1935; Furger and Hartmann 1983; Schlichtherle and Wahlster 1986; Ruoff 1991; Bauer 1999), bridged the gap between scientific accuracy (with its fear of false ideologies) and the public demand for more information or communication between research, object and public (Hooper-Greenhill 1996: 3).

The media for this were often art, education and the open-air museum which, from the outset, helped museum-based archaeology to meet its educational obligation towards the public with models, sketches, replicas, displays and scenic settings. They deciphered scientific messages that were left in the form of finds, mostly in locked display cases, for the less well-educated viewer.

Context was also set by the guide during guided tours (obligatory in some open-air museums). The variety of methods used to convey information and the impressive native of lake-dwelling finds were appealing and were the basis for a long-lasting success. But the scientific treatment of archaeological images also highlights the dangers which can occur with the rash production of images not strictly based on archaeology (Antibes 1987; Bernhardt 1992). Taking the last 150 years as an example, it must be remembered that pictorial messages must be well thought through and should, in order to avoid falsehoods, be less linked to *Zeitgeist* and fashion than to scientific results and the duty of care of the scientist (Mehling 2002: 90). At the same time, more new artistic interpretation is necessary so that, after a long absence of images in middle European archaeology, a higher quality of interpretation and visualization can develop again (Ruoff 2002: 79). In addition, research into public reception, which has been almost non-existent, even in open-air museums, is necessary, so that archaeology can endure in a society increasingly shaped by visual images.

The history of lake-dwelling museums

Beginnings in historicism

Contrary to a deep public belief, a 'phase of lake-dwelling romanticism' did not exist, according to the German prehistorian Ernst Wahle (Wahle 1950: 520) just like a '. . . romantic prehistory . . .', because the characteristics of this phase appeared only temporarily and were of lesser significance. The reality of the findings quickly overrides the perceptions. The questions they raise lead to sober criticism of the facts. Everybody who read the lake-dwelling reports of the Antiquarische Gesellschaft (Society of Antiquities) in Zurich between 1854 and 1930 or the conference reports of the influential societies of the nineteenth century, written with a scientific approach, can forgive initial misinterpretations and the romantic inflection in them. In order not to confuse cause with result one can only speak about an adaptation of the theme by historicism and historical painting, with regard to oil paintings but not scientific writings.

The portrayals of lake-dwellings were supposed to be ideal images (Heierli 1901: 96), 'constructed models' (Kaeser 2000: 67, Figure 42) or 'scenes', but not realistic reconstructions. The term *Pfahlbauromantik* (lake-dwelling romanticism) is an invention of the 1930s and 1940s (Schmidt 1930: 12; Paret 1941–2) and is connected with a dispute about the portrayal of stilt houses in the open-air museum of Unteruhldingen. This dispute provided the impetus for innovations in wetland research.

These early images illustrated the subject and made it more accessible to the broader public. They appealed to the emotions and did not claim to portray archaeological reality. On calendars and in parades (Eder and Trümpy 1979: 33) they demonstrated the ideas and sometimes just the humour of a society, which was evolving in a new way (Figure 15.1). In 1848 Switzerland became a Federal State, while in 1871 Germany became the German Reich. It was not only natural sciences and ethnography, but also the emergence of post-revolutionary ideas about national identity and statehood that caused a wider interest in history and the lake-dwellings. Historical associations and antiquity societies were founded. This process was supported by governments and rulers promoting historical awareness and by local activists. For the masses, this encouraged an increasing interaction with their own history which did not only begin in Rome or Athens for the educated classes (Wahle 1950: 106), but in Robenhausen, Mercurago or Neuveville and simultaneously fostered a sense of identity.

The Swiss lake-dwellings became popular in European eyes through the World Expo in Paris in 1867 (Furger 1998: 28) with the Schwab collection from Biel, the lake-dwelling paintings of Rodolphe Auguste Bachelin commissioned by the Swiss Federal government and the 'model of a cabin on stilts from the stone age' by the farmer Jakob Messikomer (Müller-Scheeßel 1999: 25). The next representation of finds followed in Vienna in 1873 with a five house model of a lake-dwelling by Max Götzinger from Basel (Bandi 1979: 28). Finally full scale stilt houses in a pond were envisaged by the architect Claude Garnier at the World Expo in Paris in 1889 (Garnier and Amman 1892: 17) which had a

Figure 15.1 Figures from the historical pageant in Neuchâtel 1882. Photograph: Musée d'art et d'histoire, Neuchâtel, Switserland.

display of round houses and pitched-roofed houses, based on Keller, such as one migh see in an open-air museum.

The five-house model, on a platform, based on Keller/Götzinger was further promoted in the half-sized buildings erected shortly afterwards by the shoe manufacturer Bally from Schönenwerd in Aargau. This reconstruction was not an accessible open-air museum but simply a park model (Ahrens 1990: 14; Schöbel 1997: 116). The ethnographically and archaeologically grounded conception remained effective even after Keller's death in 1881. It was in fact used in Kammer on lake Attersee in 1910 (Willvonseder 1941: 55; Offenberger 1981: 295), in the second village of Unteruhldingen in 1923–31 (Schöbel 2001: 26), in the Archeopark of Boario Terme, Italy in 1996 and finally, in Dispilio, Greece in 1999.

The fascination with the Stone Age and Bronze Age finds which were recovered from the lake bed quickly led to the new founding of new museums and to the establishment of new departments in already existing museums. In the lake-dwelling regions (Lausanne 1854, Friedrichshafen 1869, Überlingen 1871, Biel 1871, Boudry 1872, Neuveville 1877), as well as in the big cities (Rome, Bern, Vienna, Berlin, London, Paris), the political restructuring of Europe created a high demand for artefacts, which was evident both from the growing number of collectors and from purchases and trade by museum professionals and amateurs. The daily press reported the discoveries in countless articles, and engravings of lake-dwellings became popular illustrations in weekly papers. 'The lake-dwellings and their inhabitants' were taught at school in Prussia and Switzerland and featured in easy-to-read popular literature (Pallmann 1866; Staub 1864). 'Rulaman' (Weinland 1876), a story about cave bear hunters and lake-dwellers, was published in several editions for young people. Conferences and meetings like those of the Deutsche Anthropologische Gesellschaft at Lake Constance in 1877 not only drew well-known enthusiasts and ancient historians to the site of the discoveries, they also provided forums for the reconsideration of the subject of prehistory, which had originally been viewed as a science complementary to physical anthropology. Rudolf Virchow, a renowned physician, museum founder and social anthropologist from Berlin, Johannes Ranke from Munich (the first holder of the chair of anthropology in Germany), Jakob Messikomer, Oscar Fraas and Victor Gross all attended the meeting in Constance, during which they visited the museums of Schaffhausen, Überlingen and Frauenfeld. At the site of Niederwil the remains of the lake-dwellings were exposed for the guests. The phrase 'researching and collecting should be done by hand – and everything else should be left to the future' by the local archaeologist Diaconus Steudel from Constance describes pretty accurately the mindset of a field of research still in its infancy.

Collecting, describing and displaying is important, or to borrow a phrase from the founder of the Rosgarten Museum in Constance, the pharmacist Leiner: '. . . I want to collate artefacts which are speaking evidence for the development of the area from the beginning through all periods.' This phrase is still valid for most of the current regional museums.

Great conferences such as the ten-day event in September of 1899 in Lindau, held in conjunction with the Vienna Anthropological Society, with 385 participants and an international panel, are evidence for the unwaning interest in this field of research, which crossed national boundaries. The collections of Bregenz, Wetzikon, Zurich, Biel and Bern were visited. Oscar Montelius from Stockholm lectured about the chronology of lake-dwellings and dated the Stone Age lake-dwellings back to 3000 BC. Moritz Hoernes from Vienna considered the beginnings of artwork and explained the dating of early bronze and copper finds from Austria and Switzerland. The anthropologist Kollmann discussed the five fingertips of a female lake-dwelling potter with the help of finger imprints found on the bottom of a vessel from the lake-dwelling at Corcelettes which Forel obtained from Morges. The base of this vessel was introduced for the first time as a further example of an experimental approach and of tracing evidence in the *Gazette de Lausanne* on 7 April 1879 and also in *La Nature Paris* in June of that year.

Curiosities but also simple finds from lake-dwellings became available to those interested in culture all over Europe. The 1890 publication *Lake-dwellings of Europe* by Munro which described, in English, the most important finds is one example of this. Of no lesser significance is the book by Victor Gross *Les Protohelvètes* published in 1883, with 950 photographs of lake-dwelling artefacts. This work was inspired by Rudolf Virchow and was carried out to the highest standard. The compendia and museums guides completed this first phase of research. Prehistory had established itself and appeared increasingly at a national level. In 1908, the Swiss Society for Prehistory published its first annual report and the Proceedings of the Prehistoric Society appeared. The Society for German Prehistory was founded in 1909 under the chairmanship of Gustaf Kossinna and in 1913 the volumes of the Prehistoric Society of Vienna were published for the first time.

Expressionism and reform pedagogy

The twentieth century was characterized by a renewed extension of the lake-dwelling research, most importantly at the Federsee Moor and at Sipplingen on Lake Constance (Schlichtherle 1997). This applied not only to excavation techniques which made increasing use of photography and natural science but also to the publication of the results in journals, popular periodicals, early films, children's books and museums. The excavations of the Institute for Prehistoric Research under the direction of Robert Rudolf Schmidt and Hans Reinerth (Keefer 1992; Müller-Beck 2001; Schöbel 2002a) created a new image of prehistory (Reinerth 1921; Coles and Coles 1989: 51) that was widely recognized. The children's books: *Walo the Lake-dweller* (Blecher 1918), *The Treasure of the Lake-dweller* (Achermann 1918), *The Cave Children in the Lake-Dwelling* (Sonnleitner 1920), *Islanders of Lake Constance* (Keller-Tarnuzzer 1935) and *Namuk the Stranger* (Kocher 1936) reflected the development from the old images of lake-dwelling to more recent ideas about stilt and bog dwellings in their illustrations. Adult readers in London, Paris, Leipzig, Berlin, Vienna and Budapest could find out all about the excavations in the illustrated reports which appeared in weekly magazines. They could also view the first Ufa-feature film *Natur und Liebe – Schöpferin Natur* (Nature and Love – Mother Nature) with scenes of the open-air museum of Unteruhldingen (Figure 15.2) (Schöbel 2002a: 326). In economically difficult times, archaeology actively pursued the incorporation of local prehistory into the school curriculum (Schmidt 1920: 9). In addition scale models were offered to both schools and museums (Rausch 1928) with the intention of making these places of public education, research institutes and colleges for a wider public (Kiekebusch 1915: 15). The aim of the Heimatmuseum (local history museum) movement was also to make the museum into an institute of public education and not just a place to house collections (Peßler 1927: 13; Roth 1990: 30). This coincided with the objectives of the Berlin anthropologist Rudolf Virchow. He saw the socio-political and education-based museum as being founded not only on reform pedagogy in Germany but also on folklore and on the ideas of the founder of the Stockholm National Museum and Rural Open-air Museum Skansen (1891) Artur Hazelius. Through open-air museums and the incorporation of labour and everyday culture into museum presentation, they shaped new exhibitions, which also strongly influenced new prehistoric foundations in this field. The newly erected sites of Biberach (1918), St Gallen (1921), Tübingen (1921), Estavayer (1925), Steckborn (1927), Stein on Rhine (1927), Bad-Buchau (1927), Schaffhausen (1928), Vöcklabruck (1932), Rorschach (1933)

Figure 15.2 Still from *Natur und Liebe – Schöpferin Natur,* Ufa, Unteruhldingen 1926. Photograph: Pfahlbaumuseum.

and Unteruhldingen (1934) were, like the open-air house reconstructions of Lindau (from 1910 to 1922), Kammer (1910–22) Unteruhldingen (1922–31) and Seengen-Riesi (1925), an indication of the adoption of new ideas focusing on a presentation more suitable to a broader public. Exhibitions increasingly featured natural sciences, now self-confidently considered as complementary sciences (Hahne 1928), models, reconstructions, teaching collections, tableaux, chronological tables, distribution maps, photographs, postcards for sale, school courses and guided tours. In tourist regions, attractive museums became even more popular with summer guests. Visitors to the Open-air Museum of Unteruhldingen on Lake Constance were 13,000 in 1923 and by 1932 the number had increased to 27,000.

Abuse during National Socialism

On the basis of what happened in the 1920s, it was easy for those responsible for museums to convert 'the new directives in the National Socialist state' into educational work after 1933 (Hassmann 2002: 107; Schmidt 2002: 147; Schöbel 2002a: 335). This concerned all museums. The lake-dwellings were particularly suitable for propaganda and played an important role in classroom education, in open-air museums and in the media with the travelling exhibition *Lebendige Vorzeit* (Ancient Times Alive) between 1936 and 1939. The bow drill and the stilt house now had its third incarnation, this time as the 'Nordic culture group' and as the 'dwelling house of the Primeval Teuton' (Lechler 1937; Reinerth 1942). The theories of the prehistorian Hans Reinerth published in the *Nationalsozialistische Monatshefte* (monthly journal of the National Socialists) of June 1932 are at the same time enlightening and disturbing in their consequences. They clearly show not only the changes needed within science, but also changes needed in the area of the National Socialist portrayal of German prehistory. The evaluation of this particular field of 'Nazi archaeology' and its political abuse has already been thoroughly investigated, in contrast to the attitude towards other historic peoples like Vikings, Slavs or Romans which also served as models for fascism and nationalism (Ahrens 1990; Keefer 1992; Arnold and Hassmann 1995; Schöbel 2001). Nationalism, the didacticalization of education and the overemphasis of the 'national' question by Kossinna presented the opportunity to raise the profile of archaeology in politics and society and to create new posts and institutions. The 14 new chairs of prehistoric archaeology created in Germany between 1932 and 1942 are the quantifiable evidence of this development.

The merry lake-dweller at the cosy campfire mutated now into a sinisterly staring Teuton. The 'war likeness', 'Führer principle', and the 'high culture of the Germans' were now taught according to the curriculum. The museum visit within the framework of school outings and 'Strength through Joy' trips initially raised visitor numbers in the open-air museums, which captured the imagination of the people through their atmosphere and tourist attractions. The Open-air Museum of Unteruhldingen received its third village with the addition of the Stone Age settlement of Sipplingen between 1938 and 1940 (Schöbel 2003). At the same time, visitor numbers dropped from 60,000 to 16,000. In Radolfzell at Lake Constance a new Open-air Museum of German Prehistory had been established in 1938 with Mesolithic cabins and Neolithic houses. Plans were made for a 'Great Open-air Museum' in Unteruhldingen, including the demolition of the part built before 1931and its replacement with 25 new houses. Another museum with 24 houses was planned for Bad-Buchau. Both these plans were halted by the war. At the exhibition 'From Ring Wall to Bunker, 3000 Years of History of the Fortress Metz' in June 1944 there was, strangely enough, a four-house lake-dwelling model after Keller, as proof of Germanic fortress-building displayed beside Germanic fortified villages aimed at the military indoctrination of the French population (Schnitzler *et al*. 2001: 112).

In Switzerland two collections opened in 1937, one in Steckborn on the Southern shores of Lake Constance in a new form and the other, the Irlet Collection, in Twann on Lake Biel. Prehistory incorporating the lake-dwellings formed an important part of the Swiss national exhibition *Heimat und Volk* (Home and Folk) in 1939 (Laur-Belart 1939) and played a significant role in the 'Spiritual National Defence' against their Italian and German neighbours (Rückert 1998: 89). Reinhold Bosch conducted practical projects, initially in 1934, with unemployed teachers at Baldegger See, then from 1942 with students of the District School Seengen and finally in his own Stone Age workshops near Seengen and Halwil. Among those practical activities was the drilling of stone (Bosch 1963–5). Also notable is the excavation at the lake-dwelling of Biskupin in Poland by the archaeologists Rajewski and Kostrzewski, the latter a student of Kossina in 1934. The excavation became internationally well known, just like that at Wasserburg Buchau by another of Kossina's disciples Hans Reinerth ten years before. In Biskupin the outstanding quality of preservation, the use of best methods and a concerted publicity campaign with films and popular articles attracted more than 400,000 people to the site between 1934 and 1939. The first reconstructions of a settlement, which had begun a few years before, were totally destroyed by the SS-Ahnenerbe (SS Heritage Association) during the war years 1940–1942 (Coles and Coles 1989: 57; Niewiarowski *et al*. 1992: 81). These were rebuilt only after the war. In 1941–2, the theories of Oscar Paret, a long-time opponent of Schmidt and Reinerth's research since the beginning of the Federsee excavations, had a huge impact: '. . . The stilt houses are a romantic invention, an error, a scientific fable and never existed.' More than 300 newspaper articles appeared in the year 1942 alone in the German-speaking areas and in the occupied territories, in Linz, Leipzig, Strasbourg, Breslau and Lemberg. In the background the Reichsicherheitshauptamt (NS office for internal security) and the research society the SS-Ahnenerbe conspired to spread the anti lake-dwelling theories. These theories were intended more to discredit the protagonist Reinerth and his office in the Amt Rosenberg, than the stilt house reconstructions of the nineteenth and early twentieth centuries (Schöbel 2001: 78). Nevertheless, these theories still have a detrimental effect today as was proved by the Troy dispute which flared up recently. In this case, the scientific theory which had originally been accepted has now been disproved by subsequent research.

However, despite this, the original idea still holds sway in the popular imagination. This underlines the power of images.

Post-war era and an overemphasis on science

In the post-war era in Germany and Switzerland, in contrast to Italy, Slovenia and Poland, academics initially showed a reluctance to engage in lake-dwelling research. In the new image of prehistory (Paret 1948) stilt houses did not exist any more. Swiss classroom pictures, house reconstructions and museum paintings (Guyan 1943) like those of the bog settlement of Thayngen in the museum at Schaffhausen, depict cabins with sawn-off posts and demonstrate in a simplistic way, as in the municipal museum at Überlingen (1946) or Friedrichshafen (1957), suggested constructions with the floors of the houses elevated (Reinerth 1921). Criticism from Germany (Furger 1998: 44) and new examinations of the Wauwiler Moos led, mainly through the Zurich Ordinarius Emil Vogt in Switzerland, to the temporary rejection of the lake-dwelling theory in favour of the idea of houses at ground level. The lake-dwelling question re-emerged again in the 1970s, as a result of the excavations in western Switzerland, Upper Italy and at Lake Constance (Strahm 1983). Nevertheless there was also a wave of new foundations of smaller museums in the heartland of the lake-dwellings: Biel (1945), Wetzikon (1959), Schötz (1960), Neuchâtel (1962), Halwil (1962), Pfäffikon (1964), Zug (1964).

The research became apparently more representative but also more serious (Figure 15.3, top and bottom). Years of research for example, culminated in a big exhibition by the Swiss National Museum (The First Farmers 1990), held in Zurich in 1990. Similarly, the model project 'Laténium' (2001) in Neuenburg presented in a new architectural setting the connection between nature and culture (Egloff 2002) and showed new and old archaeological treasures. The Musée Schwab in Biel houses the new arrangement of the most relevant finds from the early days of research and finally, the regional Hans Iseli Collection was accorded the status of lake-dwelling museum in Lüscherz in 1995, just like many other private collections before and after.

With a few exceptions of course, the post-war German research was not very active until the work of Schlichtherle in 1973. The only new opening was the Federsee Museum in Bad Buchau in 1967. It is interesting to notice that the museum building, designed by the architect Manfred Lehmbruck, was itself on stilts. Exhibition activity was revitalized again with the redesign of the Stone Age section in the Württembergische Landesmuseum in Stuttgart in 1989.

In 1992 the Archaeological Museum of Constance opened, and had exhibits showing the actual lake-dwelling archaeology in Baden-Württemberg. In Bad Buchau 12 full-scale reconstructions were built with funding from the EU in 1998/9 to supplement the exhibition redesigned in 1995. In the Open-air Museum Unteruhldingen founded in 1922 by the regional Lake-Dwelling Association, a new museum building was opened in 1996 based on a new conception. In the third group of buildings (1922/3, 1931, 1938–40) the Neolithic

Figure 15.3 Top: exhibition room of the Institute of Prehistory, University of Tübingen 1958. Bottom: 'Lake-Dwellings' exhibition room of the Württembergisches Landesmuseum, Stuttgart. Top photograph: Hellmut Hell, Reutlingen. Bottom photograph: Württembergisches Landesmuseum Stuttgart.

'Hornstaad house' was erected in accordance with the results of research from Lake Constance. The film 'Stone Age Mouse' which was shot during the 20-day reconstruction explains the findings. The late Neolithic 'Arbon house' was presented in 1998 as a joint project with Swiss archaeology (Thurgau), which in 1996 had redesigned the Kantonale Museum in Frauenfeld (see Chapter 16; Schmidt 2000: 75). Finally, between 1999 and 2003 the 80-year-old open-air museum was expanded to 20 houses by the addition of a Late Bronze Age village based on underwater archaeology conducted by the State Monuments Office between 1981 and 1998. Thanks to its rich finds in the Po Valley and on various lakes in the north, Italy became the focus of research in the second half of the twentieth century. The museum of Trento even created a small lake-dwelling museum with open-air reconstructions on Lake Ledro in the late 1960s. The site of Fiavé, with its remarkable stilt house structures, and the settlement of Lavagnone in the Lake Garda region restarted the lake-dwelling debate (Perini 1987: 75; Marzatico 1988: 13 and 50). In Poviglio, the heavily reinforced *Terramare* settlements started a new phase of research in 1984. This led to a resumption of research in Montale near Modena from 1998 onwards and in 2000 to the creation of an archaeological *Terramare* park with a museum as part of an EU project in conjunction with the Vienna Natural History Museum and the Unteruhldingen Museum (Cardarelli 2003; Schöbel 2003). In Austria a lake-dwelling museum was founded at the Mondsee in 1953, displaying the finds from the lake. Moreover, underwater archaeological research which was conducted in the Salzkammergut in the early 1970s led to the development of plans for a new open-air museum in cooperation with the regional tourism office (Offenberger 1981: 295). In Poland the Lusatian fortified village of Biskupin was rebuilt with an adjoining scenic park and exhibition hall based on ongoing research (Zajaczkowski 1994). In Araisi in Latvia the re-erection of an open-air museum in 1980 was based on the survey of a ninth-century AD island settlement carried out between 1959 and 1964 (Apals 1994: 97). At Lac De Chalain, France, archaeologists led by Pierre Pétrequin created an open-air reconstruction based on ethno-archaeology and experimental archaeology in 1989. They let these reconstructions decay naturally in order to validate theories concerning the original finds (Pétrequin 1997: 100). In the UK, 'hands-on' house reconstructions similar to the known models of Scottish and Irish crannogs and fenland settlements (Pryor 1991: 65; Cox 1993: 24) were created within their original environments, reconstructions which could not only be analysed by scientists but could also be temporarily inhabited and experienced by museum visitors. This idea is not new and can be traced back to Hans Hahne in 1918 who built an experimental house based on the Rössen finds, commissioned by the manufacturers Leuna (Hahne 1919) and to Robert Rudolf Schmidt (Keefer 1992: 33) who, in 1920, also reconstructed a house in Wilde Ried near Buchau. This kind of reconstruction was inspired by 'living history' projects in Scandinavia and England, Hans Ole Hansen's living experiments in Lejre, and Peter Reynolds' Butser Farm Project. They had, without doubt, a decisive impact on the development of many European open-air museums.

Conclusions

The lake-dwelling museums took various forms in the past; from old displays with educational purposes to political vehicle for national identity; and from idyllic landscape for tourists to experimental laboratories. They now stand on the verge of being museum parks and event centres. This brings a requirement for

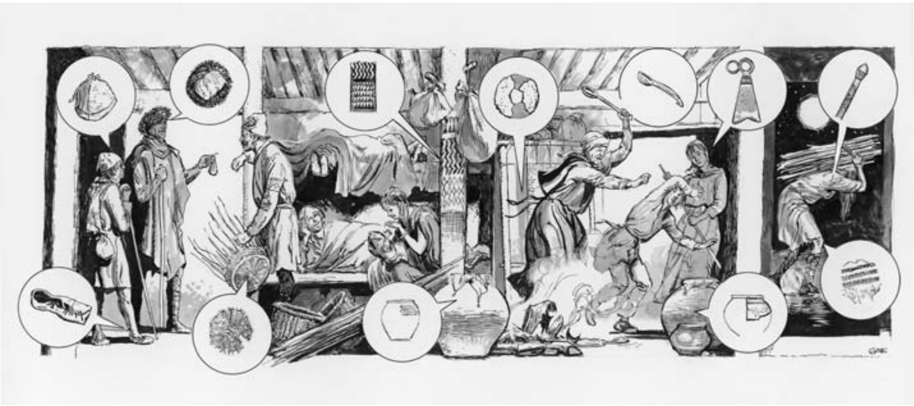

Figure 15.4 Top: tableau of the Late Bronze Age with integrated replicas. Bottom: Hallstatt merchant meets Lake-dweller. Photographs: Pfahlbaumuseum, Gerry Embleton.

quality standards and a clearly defined profile for European open-air museums which are in the process of being developed for archaeological institutions (Schöbel 2002b). The new institutions do not necessarily present a better solution for the public than the more established ones. The aforementioned lake-dwelling museums do not differ greatly from other cultural institutions which have undergone a similar development over the past 150 years. Too much political and social interference caused a counter-reaction within the scientific community. The trend towards an over-emphasis on science should be reversed and a more public-orientated research should be part of the academic task.

New research has always proved to be very beneficial and has led to many new exhibitions. There is an important connection between analysing and conveying the results of research: ideally there is cross-fertilization between these two objectives. Private initiatives and collectors with an interest in lake-dwelling research have played an important role alongside official organizations independently of scientific developments, which have led to the founding of many new museums. The existing methods of presentation are always subject to improvement in the eyes of the public. The standard in schools, museums, books and the media must be raised. The visitor requires more educational content, artistic interpretation and personal experience than is provided by the mere display of artefacts, including the explanation of scientific methods and analysis. At present, museums are not using their full range of possibilities to achieve this. The visitor these days is able to discriminate between an artificial theme park and the authenticity of an open-air museum that explains the present through the reality of the past. Dry scientific data are not in themselves appealing to the public and competition in the field of education is increasing. The mediation of artists and craftsmen is needed therefore (Figure 15.4, both panels). Despite their rejection by lake-dwelling research in the past, a modicum of romanticism and humour, popular appeal, easy-to-understand and carefully researched images and stories is needed in order to be acceptable to the public. How else should we meet the needs of the visitor?

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16

EXPERIMENTAL AND APPLIED ARCHAEOLOGY IN LAKE-DWELLING RESEARCH

Urs Leuzinger

Introduction

Despite the excellent preservation conditions in the pile dwellings along the lakesides of the Alpine region, only fragments of many of the finds and remnants of the features in particular come to light. It is, therefore, often necessary to fill in the missing pieces in order to illustrate the original function of the millennia-old remains. Neolithic arrows may serve as an example of this phenomenon: unlike the numerous flint arrowheads, the wooden shafts are extremely rare. The fletching, which is necessary to ensure the optimal trajectory of the arrow, is an even more unusual and always fragmentary find – as was the case with the arrows that belonged to the 'Man in the Ice'. That is why reconstruction drawings, models of houses and replicas were created as early as the nineteenth century (Speck 1981: 104, 106). Even at that time, these methods were not applied for the sole purpose of scientific understanding, but mainly for didactic reasons, in collections and museums. Who of us has not tried out the bow drills used for making shaft holes in stone axes that were on display for the public to experiment with in numerous old local history museums (Zurbuchen 2001: 23)?

Experimental archaeology

Academic and non-academic institutions dedicated to experimental archaeology, especially where lake-dwelling sites are concerned, have existed for decades in every country which is rich in well-preserved archaeological remains. It is obvious that experimental research always includes topics from the field of pile dwelling archaeology. The Lake-dwelling Museum of Unteruhldingen (Germany) opened as early as 1922. The hugely popular success of this open-air museum at Lake Constance led to the opening of new pile dwelling parks displaying individual houses or entire villages from the Neolithic period or the Bronze Age. They have appeared in many places over the past few years – often supported by EU funding. Examples of some recent parks are Bad Buchau (Germany), Chalain

(France), Lago di Ledro (Italy), Senales (Italy), Montale-Rangone (Italy), Umhausen (Austria) and Gletterens (Switzerland). Besides these open-air parks there are also numerous people who try to fathom out prehistoric techniques by means of experimental reconstructions. The problems surrounding these research projects result from the difference between purely scientific experiments and hands-on archaeology. For example, the 'Swiss Society for Experimental Archaeology' (Arbeitsgemeinschaft für Experimentelle Archäologie der Schweiz – AEAS), founded on 21 March 1998, tries to bridge this gap with a deliberately open approach. In principal, the following five activities are on offer:

- Experiencing situations based on archaeological evidence
- Learning and teaching techniques and skills from times past
- Offering demonstrations or using reconstructions in research, classrooms or exhibitions
- Carrying out scientific experiments
- Documenting, recording and publishing results.

Given that hands-on archaeology as well as strictly scientific experiments (Kelterborn 2001a: 21–3) are elements of the society's principle, the AEAS provides a suitable stage for satisfying diverse demands ranging from museum education on the one hand, and university research on the other. It is no secret that this polarity is precisely what leads to a certain amount of tension between experts. Hence, there are ongoing attempts, particularly in Germany and France, to counteract the enormous proliferation of 'archaeological self-discovery-workshops' and 'archaeological Disney Parks' of dubious quality, by defining quality standards or 'seals of approval' (Schmidt 2000: 170–1). The organization 'European Exchange on Archaeological Research and Communication' (EXARC) was founded for the same reason in 2001. The intention of the 11 open-air museums which were the founding members of EXARC, among them the Lake-dwelling Museum of Unteruhldingen, is to guarantee that the range of experimental archaeology on offer is of a high quality as well as scientifically correct, self-critical and well documented (Schöbel 2002).

The next section introduces a number of examples of archaeological experiments involving pile dwellings. It goes without saying that these projects only represent an extremely small number within a multitude of experimental endeavours and the examples selected do not give a balanced representation of all such projects.

Reconstructed pile dwellings: model on a scale of 1:1

As well as numerous seeds, fruits and organic artefacts, remains of wooden houses have also been preserved thanks to the constant moisture of the sediments in pile dwelling villages. Dense concentrations of piles, which nowadays often lie in the shallows of the lakes, are the results of several chronologically successive villages built at the same settlement site. It was realized as early as 1854 that these piles must represent remains of buildings – thus the pile dwelling theory was born (Keller 1954) and the famous reconstruction drawing was made and reworked several times during the following decades (Kaeser 2002: 33–41). The remarkable feature of the response to this early image is the multitude of technical solutions suggested for the upright parts of the buildings. Rectangular buildings and round huts with several different roof constructions were depicted. It is obvious that parallels from ethnology and folklore were the main models for the image. These roughly sketched early reconstructions allowed full rein to the *Pfahlbaumythos* (the notion of dwellings on platforms in the lake); more than a century passed before it was possible to rectify this false image among the general public at least to some extent.

On the initiative of the local mayor Georg Sulger and the archaeologists Richard Rudolf Schmidt and Hans Reinerth from Tübingen, two houses were reconstructed on a scale of 1:1 in accordance with the evidence from Riedschachen (Germany) in the bay of Unteruhldingen (Germany) as early as 1922 (Schöbel 2001). These two buildings quickly became public attractions. This is illustrated by the fact that more than 6,000 people had already visited the new open-air park by the end of that year. Additional buildings, some of which can be seen in the Lake-dwelling Museum of Unteruhldingen to the present day, were erected in the years 1931 and 1938–40. The reconstruction of these houses was strongly influenced by the extensive research excavations carried out by Hans Reinerth at the Federsee and at Lake Constance.

The Lake-dwelling Museum and its innovative and creative Society gradually fell under the influence of National Socialist ideology and politics from the early thirties onwards. The active National Socialist Hans Reinerth was the driving force in this. The political influence on his archaeological work is demonstrated clearly, for instance, in the renaming of a reconstruction of the Wasserburg (water castle) Buchau from 'manor house' to 'leader's house' (*Führerhaus*) (Schöbel 2001: 55). When Gunter Schöbel took over as the head of the museum in 1990, the varied and in some respects highly controversial political past of the Lake-dwelling Museum of Unteruhldingen was researched and published in full (Schöbel 2001). Representing all experimental reconstructions, this particular history of research therefore clearly shows that archaeological interpretations always have to be seen as part of the spirit of the times and in light of the state of research.

Since 1996 new houses have again been reconstructed in the open-air park at Unteruhldingen in accordance with the evidence obtained at excavations; among them a building from the Late Neolithic settlement Hornstaad-Hörnle (Germany), several buildings and a section of the palisade from the Late Bronze Age settlement Unteruhldingen-Stollenwiesen (Germany) and a house from the Late Neolithic village Arbon-Bleiche 3 (Switzerland). The following section briefly presents the latter reconstruction project.

The Archaeological Department of the Canton of Thurgau carried out extensive excavations in the Late Neolithic lakeside settlement Arbon-Bleiche 3 during the summer months of 1993–5. In total, an area of more than 1,100 square metres was explored. Structures which were very well preserved and many finds dating from the period between 3384 and 3370 BC made it possible to reconstruct village life and building activities during the transitional period between the Pfyn and Horgen Cultures (Leuzinger 2000; de Capitani *et al*. 2002). To coincide with the scientific examinations we were able to reconstruct house 23 from Arbon-Bleiche 3 in the Lake-dwelling Museum of Unteruhldingen during the summer of 1998 (Schöbel 1998/99: 82–91). The model on a scale of 1:1 allowed us to test and practically assess the interpretation of the evidence excavated. The double-aisled construction is eight metres long and four metres wide (Figure 16.1). The reconstruction corresponded with the evidence right down to the smallest detail. The piles used were of the same type of wood, had the same diameters as the originals and were driven into the ground at the same angles in the same places.

As there was no evidence to provide information on what the upper parts of the house had looked like, we were forced to speculate on how to use the constructional elements that had been excavated such as collapsed timbers, baste ropes and pieces of fired daub. The evidence documented during the excavation suggested that the houses in Arbon-Bleiche 3 contained raised floors (Leuzinger

Figure 16.1 Reconstruction of house 23 in accordance with evidence excavated at the Late Neolithic settlement of Arbon-Bleiche 3, Switzerland. The reconstructed house from Hornstaad-Hörnle can be seen in the background. Both reconstructions are in the Lake-dwelling Museum of Unteruhldingen (Germany). Photograph: Urs Leuzinger, Archaeological Department, Canton, Thurgau.

2000: 166–9). The building stands in the vicinity of an embankment so the floor had to be raised by between 0.4 and 1.4 metres. The model of the house can therefore be used to show that the height of the floor depends mostly on the location and the building ground. The level of the floor is situated at 397.21 metres above sea level and therefore lies below the 100-year mean high water mark of Lake Constance (397.75 m asl). The extreme high water that occurred during the summer of 1999 flooded the floor of the reconstructed house by an average of half a metre over a period of several weeks. The water, however, did relatively little damage to the building. Bindings that came into contact with the water had loosened and merely had to be re-tied. The walls consist of vertical silver fir boards on one hand and horizontally and vertically bound stakes on the other. The cracks between the boards were sealed with *Neckera crispa* moss, a substantial quantity of which was found within the organic cultural layer. The roof consisted of silver fir boards, which were tied to the collar beams as shingles and additionally secured with long poles. In order to protect the bindings from the weather, the few exposed areas were covered with sandstone slabs or pieces of bark. Several summer thunderstorms and force ten gales have shown that the roof construction is weatherproof and watertight. Some leaky spots could be sealed perfectly without much trouble using waste from the making of boards. Modern tools were used to prepare the timbers and to build the house. The bindings were made of industrially manufactured hemp as well as in some cases lime baste.

The next few years will show where building flaws have crept into the reconstruction of building 23. One of the main goals in reconstructing the house is to recognize and document these flaws. Furthermore, thanks to the prominent location of the Arbon house within the open-air museum of Unteruhldingen, more than 1.5 million visitors have been able to gain a three-dimensional insight into the interpretation of the evidence found at the Late Neolithic lakeside settlement Arbon-Bleiche 3.

The project run by Pierre Pétrequin in the shallows of the Lake of Chalain (France) is of special interest to pile dwelling research. Together with his team, he built two houses there in 1988–9 using the evidence obtained from the Late Neolithic settlements of Chalain and Clairvaux (Pétrequin 1991). Both the buildings have raised floors and are built on the flat, calcareous mud shore, which is flooded seasonally. The houses were lived in for several months at a time over a period of seven years. Additionally, crafts were practised, agricultural activities were carried out and numerous meals were cooked inside and in front of the houses every year; waste as well as finished products were left on the spot or consumed respectively. For the past few years the two buildings have no longer been looked after, but have been deliberately left to decay (Figure 16.2). The interplay between destruction by the weather, erosion by the lake and possible embedding due to lake sediment deposits will provide valuable knowledge of the genesis and alteration of the cultural and rubble layers which have formed in the course of experiment. In future this may well enable us to draw comparisons with the archaeological layers deposited in lakeside settlements, which are, as a rule, extremely complex.

Figure 16.2 The Neolithic house from Chalain, France, reconstructed by the Centre de Recherche Archéologique de la Vallée de l'Ain fell on to the ground in 2002 and was left untouched where it fell, so one can still see how it was built. The construction is deliberately being left to decay. The floor, which was originally 1.2 m above the ground, collapsed, but remained intact in 2002. Photograph: Urs Leuzinger, Archaeological Department, Canton, Thurgau.

Reconstructing objects

Many archaeologists working with finds from lakeside settlements use experimental research as part of their technological and functional artefact examination. This includes various groups of materials such as stone, pottery, bone, tooth, antler, metal, textiles and wood. This part of the chapter briefly introduces four arbitrary examples of mostly scientific studies.

Flint arrowheads

Peter Kelterborn (2000: 37–64; 2001b: 48–57) recently examined 89 flint arrowheads from the Horgen lakeside settlement at Hünenberg-Chämleten (Switzerland). After analysing the technological aspects of the original finds in detail P. Kelterborn made replicas that were as close as possible to the originals. It turned out that the projectile points were not made from flint waste, but they rather, were manufactured from specially prepared flat flakes or blades, which had the length, width and thickness required. The intended arrowhead was projected into the basic form in such a way that it was possible to translate a schematic concept of a shape chosen in advance with the least amount of effort, while at the same time making the most of the material. Characteristic arrow wounds were documented and typical re-sharpening patterns were defined by carrying out numerous shooting experiments. More than half of the Neolithic arrowheads showed impact damage, 29 per cent of which was repaired by re-retouching. The shooting experiments also showed that the triangular points with concave bases must have been hafted to the wooden shaft not only with birch tar, but they must also have been tied on originally with a string below the hafting notch because this was the only consistent way to prevent the arrow shaft from splitting. This is consistent with the few cases in which preserved wooden shafts with corresponding flint arrowheads were found. In his scientific experiment P. Kelterborn attached importance to the following requirements: the experiment was carried out with a pronounced emphasis on the results, not on the experience itself, and the goal was to answer precise archaeological questions. The arrows were fired in a workshop, where the shots could be measured and repeated. Authenticity of the environment was not a factor. The recognition of repairs on Late Neolithic flint arrowheads in particular shows how much coincidence is in fact involved in the evidence provided by meticulous typologies. Repeated re-sharpening can quite possibly turn a long and narrow point into a short and broad arrowhead.

An insole with curative properties

In the summer of 2000, road repairs made it necessary for the Archaeological Department of the Canton of Zug to carry out a small excavation in the Neolithic lakeside settlement at Zug-Schützenmatt (Switzerland), which dates from the period around 3150 BC (Hochuli 2002: 45–54). One of the finds from that excavation was a rather unspectacular moss pad (*Neckera crispa*), which turned out to be the insole of a Late Neolithic shoe 'size 4 (37)'. The imprint of a strip running across the bottom of the moss insole from Zug-Schützenmatt is especially remarkable, as there was a strip of leather on 'Ötzi's' right shoe that ran under the shoe at a similar place (Reichert 2000: 69–76). This strip probably provided extra grip on slippery ground.

Anne Reichert made a moccasin-like leather shoe replicating a Bronze Age find from Buinerveen (Netherlands) and put a thick pad of *Neckera crispa* moss into the replica (Figure 16.3). The moss pad was quickly compressed when she wore the shoe and additional material had to be inserted repeatedly. After a while the insulation mass had become matted and had been slightly pushed upwards at the edges. According to A. Reichert it is very pleasant to walk around in such softly moss-padded shoes and the feet stay nice and warm. The negative imprint of the leather strip under the sole began to appear – as in the original find – shortly after she started to walk around on the recreated shoe.

As unspectacular as this moss insole from Zug-Schützenmatt seems to be and as anecdotal as A. Reichert's experiment appears – hardly a dozen Neolithic shoe fragments have as yet been discovered throughout Europe (Hochuli 2002: 48).

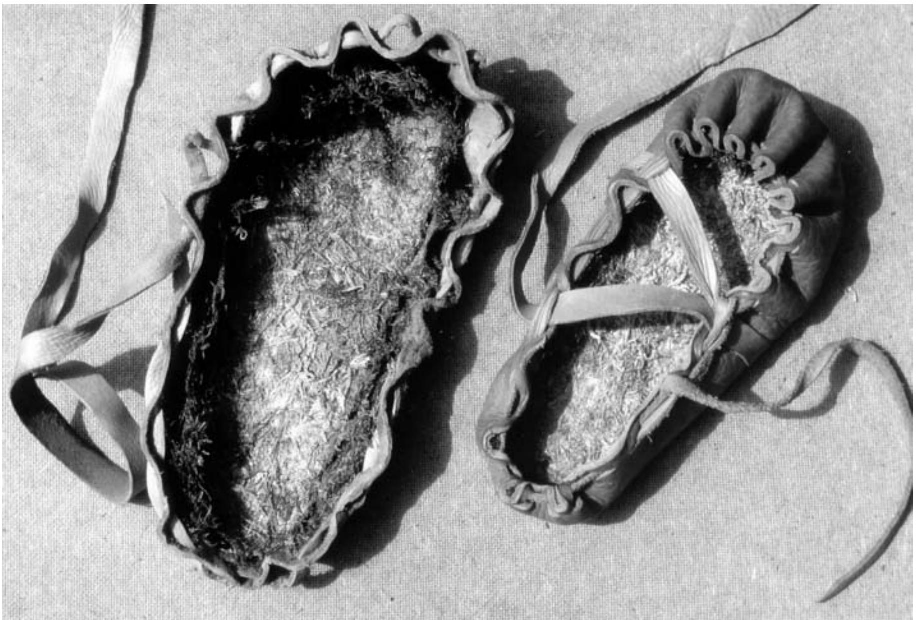

Figure 16.3 Recreated leather shoe with a 'curative properties insole' made of *Neckera crispa* moss. The original moss insole was found in Zug-Schützenmatt, Switzerland. Reconstruction and photograph: Anne Reichert.

The body of finds is probably so limited because leather remains have not been preserved in the prehistoric lakeside settlements near the Alps. Moss pads, however, are often excavated in pile dwelling settlements. They are interpreted as sealant used in house building or possibly as prehistoric toilet paper. In future it would be highly desirable to pay more attention to this unspectacular category of finds – this will probably lead to a welcome increase in finds of shoe parts.

Lance casting

Several clay mould fragments came to light in the Late Bronze Age lakeside settlement Zug-Sumpf (Switzerland). They were found inside the group of houses 3 and 4 and date from the time between 1043 and 963 BC (Seifert 1997: 77–8). Jeanne Bonzon of the Institute for Mineralogy and Petrography at the University of Freiburg (Switzerland) examined the raw materials of these artefacts. The moulds consist of a poor siliceous matrix, which was tempered with fine granite grains. The mass also contained organic material such as hair, smashed bones and probably dung. Markus Binggeli carried out six experimental casts using these data (Binggeli 2002: 44–6). Several bivalve lance-head moulds were made using a mixture consisting of 50 per cent clay, 30 per cent cow dung, ten per cent cow hair, eight per cent granite grains and two per cent bone. A carved wooden lance on one hand and an original bronze point on the other served as models. A clay cone was fixed into the right position with a copper pin to cast the hollow socket. The two holes left by this pin were later used to attach the lance head to the wooden shaft. After they had partially dried in a controlled environment the two mould faces were covered in a three to eight millimetre-thick coat of clay, completely dried and then open-fired at a temperature of approximately 750 degrees Celsius. After the moulds had cooled down to 300 degrees Celsius, the bronze (alloy used: 91 per cent copper, 9 per cent tin) was then poured into them. Three of the six cast experiments turned out perfectly, the remaining three were unsuccessful. One may assume that the Bronze Age casters had a much higher success rate – after all no one is a born expert. The experiment showed that it was possible to make moulds for producing sophisticated cast products using the locally available raw materials – except for the imported metal – provided one had the required knowledge and skill.

Combs

Combs are not just purely utilitarian objects, but can also be seen as part of a person's attire or jewellery. Therefore, different shapes and manufacturing techniques indicate specific cultural and social backgrounds. The principal question is: why have so few Neolithic combs been found? On one hand, one must certainly consider the chances of the fragile combs being preserved; however, a large number of the combs could also have been made of horn: this material has not been preserved in the lakeside settlements over the millennia (Winiger 1996: 2–33). Seven combs made of little *Viburnum* twigs were found in Arbon-Bleiche 3 (de Capitani *et al*. 2002: 101–3). Replicas of these combs were needed so that they could be shown in the special exhibition 'grösser, schöner, stärker – vom Auffallen bei Mensch und Tier', 'larger, fairer, stronger – making an impression in the human and animal worlds' at the Archaeological Museum of the Canton of Thurgau (Switzerland). The idea was not to just present the original exhibits behind glass, but to provide visitors with the opportunity to test the combs themselves. Wulf Hein was commissioned to experiment with producing three combs like those found in Arbon-Bleiche 3. At first he complied exactly with the information given in the published finds catalogue (de Capitani *et al*. 2002: 101). It soon became evident, however, that the technique described by the archaeologist, according to whom the combs were made from two-millimetre-thick 'unsplit squared twigs', could not be correct. *Viburnum* twigs with a two-millimetre diameter cannot be squared, as this would only leave pith! The twigs for the combs from Arbon-Bleiche 3, therefore, were made from carved cleft twigs. In this case the theoretical description formulated in the office was rectified by a practical, experimental reconstruction.

Archaeobotanical experiments

It is not just prehistoric houses and tools that are being reconstructed, but also entire miniature cultural landscapes. The research that has been taking place over a period of several years on the Forchtenberg in the Hohenlohekreis (Germany) is the example discussed here (Rösch 2002: 68–73). A group of farmers, geographers, biologists, forest wardens and archaeologists started to carry out cultivation experiments in relation to prehistoric agriculture in 1997. The goal of this field research is to carry out experiments in order to test the ideas about Late Neolithic forest and field cultivation formed in the course of archaeological examinations of settlements in the foothills of the Alps. The experiments are conducted in small slashed and burnt areas. Short-term cultivation with subsequent forest fallow is compared with continuous cropping, the consequences of forest pasture by goats are assessed and the advantages and disadvantages of summer and winter sowing are evaluated. In addition, not only are the amount of crops, the vegetation, the supply of nutrients, the soil biology, the pollen rain, charcoal deposits and climatic conditions examined, but also the effort involved in clearing the land using the slash and burn procedure, in cultivating the ground and in harvesting the crops using replicas of prehistoric tools. The first results are already available (Rösch 2002: 72). It has been shown for instance that it is the favourable option to slash and burn in autumn after felling during the previous year. Sowing was carried out a few days after the fire. Weeds were no problem during the first year. The average wheat yield was 23 times the sown amount, which can be seen as a good result. The gluttonous tendency on the part of the local wood mouse population proved, however, to be more of a problem. Continuous cultivation of the same patch of land is problematic. The weeds– thistles, willowherbs, raspberries and grasses – actually start to suffocate the crop after just one year. Despite intensive weeding, the amount harvested did not greatly exceed the amount sown. Future research and experiments in the Forchtenberg experimental grounds aim to solve these problems and provide a better understanding of the complex ecological causal connections.

Excellent conditions in the lakeside settlements around the Alps have also resulted in the preservation of textiles. Textile remains and pieces of flax string (*Linum usitatissimum*) constantly come to light. Besides this, waste products as well as possible tools (flax combs) for producing fibres are also often found. By means of planting experiments and archaeological finds, Antoinette Rast-Eicher and Saskja Thijsse have tried to recreate the cultivation and processing of flax in the Late Stone Age (Rast-Eicher and Thijsse 2001: 47–56). In Lelystad (Netherlands) flax was cultivated in several different experimental set-ups from 1990 to 1995. The goal was to determine the best method for cultivating and sowing in order to achieve a maximum quantity of linseeds and fibres. The field was located in a forest clearing and had to be abandoned after two years because the plants and seeds were practically destroyed by forest animals and birds. The experiment was more successful after the field had been set up near a house and a wattle fence had been built around it. The best results were achieved by sowing the seeds in 0.5-cm deep furrows 7 cm apart. Sowing in furrows also made harvesting significantly easier afterwards. The ripe seeds were gathered by picking the yellow-brown capsules directly from the plants. The stalks were then pulled up by their roots. The stalks had to be retted to harvest the fibres by either scattering them on a meadow (dew retting) or by steeping them in water (pond retting). The fibres turned beige to dark brown depending on the technique used.

Nowadays flax is broken, scotched and hackled after retting. These phases of the work process can also be identified on flax fibres found in mediaeval weaving cellars in Winterthur (Switzerland). In the scanning electron microscope (SEM) they showed characteristic fractures, shifts and compressions. In the case of Neolithic flax fibres found in the region of the Lake of Bienne (Nidau, Switzerland, *c.* 3400 BC) the SEM showed that the fibres were remarkably well preserved. They displayed practically no fractures and some of them were even still linked together. A. Rast-Eicher and S. Thijsse managed to reproduce the same evidence in their experiments. Thus, in Neolithic times the stalks were not broken with flax mallets, but simply snapped manually every 0.5 to 1.0 cm. The woody tissue then fell off and the fibres could be taken out. Two hours of using this technique produced 15 g of fibres, which were spun into a thread of 200 m length and 0.5 to 1.0 mm thickness.

Hands-on archaeology

Especially now that budget cuts are constantly on the agenda and certain political circles question the purpose of archaeological examinations increasingly often, archaeologists must leave the ivory tower of their university research every now and then. It is not just colleagues that have a right to learn about the latest discoveries in archaeological research through fat catalogues and dry reference books, but also the interested public – after all it is only the tax payers that enable prehistorians to examine the length and breadth ratios of stone axes, the thickness of pottery sherds or the casting techniques used to produce Bronze Age dress pins. It goes without saying, however, that only interdisciplinary and proficient research makes it possible to design a sound view of history for the general public. Exciting museums with a high standard of museum education, information to accompany field monuments, 'open excavation days', hands-on events and the provision of didactic material for teachers – for instance crates with original artefacts or good replicas as well as modern school books – are but some of the proven means by which archaeology can be brought closer to the public efficiently and permanently. Experimental archaeology has, of course, an important role to play in this endeavour. An example of this is presented in the following section.

Children's afternoon: fish soup lake-dweller style

The wide-ranging programme of events offered at the Archaeological Museum of the Canton of Thurgau in Frauenfeld (Switzerland) also includes a number of afternoons for children; the theme on one of these afternoons is 'Stone Age cooking'. A possible menu is planned together with the children, using the original finds that are on display – it is known that the lake-dwelling sites provide rich and varied information on the selection of food available at that time. It is then decided that the menu will consist of a barley stew, refined with smoked fish. Charred grains of this particular cereal are often found and pottery sherds with burnt food remains, still containing fish scales or fragments of fins, even make it possible to choose the right type of fish such as whitefish (*Coregonus sp.)* or perch (*Perca fluviatilis*) as tasty ingredients. The meal is then cooked on the fire in the garden of the museum in an exact copy of a pot found at the Stone Age lakeside settlement Arbon-Bleiche 3 (Figure 16.4). This is the moment when the children realize how practical it is to have electric cookers or matches and newspapers. Although direct proof for this technique has never actually been found in the well-researched lakeside settlements near the Alps, great attention is paid to striking fire with flint, marcasite and tinder, which are objects found consistently in lakeside settlements (Collina-Girard 1998: 20–8). Before the fish soup is finished, the topic of salt has to be addressed first. In order to avoid upsetting the demanding little gourmets, one is ready to compromise in this case and reach for the stock cube – even though definite proof for the trading of salt has not, or at least not yet, been found in the Neolithic lakeside settlements. We also spare the children from having to spoon the soup with home-carved cutlery and without plates – after all, hands-on archaeology is supposed to be fun and tasty.

Figure 16.4 Children's Afternoon at the Archaeological Museum of the Canton Thurgau, Switzerland. A prehistoric fish soup is being cooked in an exact replica of a pot found in the Late Stone Age lakeside settlement Arbon-Bleiche 3. Photograph: Margrit Lier, Archaeological Department, Canton, Thurgau.

Prospects for experimental archaeology

Experimental archaeology has today established itself as an important branch within the study of the past. Besides experiments which are purely scientific and to a wider audience often unspectacular, a wide field of hands-on activities has opened up. For the past number of decades the area of open-air museums and archaeological parks in particular has experienced a veritable boom. However, both large and small archaeological museums also now offer a programme of events that is usually extensive. Old crafts, everyday life and other types of recreations are demonstrated at these events, the quality of which varies from the good to the bad. Despite the individual experimental archaeologist's well-meaning intention of conveying knowledge, these differences in quality are responsible for potentially great damage to the discipline; namely in cases where the parks and their activities are degraded to the level of arbitrary playgrounds under more or less scientific guise (Schmidt 2000: 170–1). In these cases the primary goal is to obtain subsidies for economically less-favoured regions, money which one hopes to make from the expected tourist hoards, and all too often it is only about quantity and not quality. It is also often forgotten that, having launched the open-air park with outside capital, there will still be a need for funds in order to keep the venture going. Continuous funding, however, is in most cases not guaranteed. At the end of the day, it will always be quality, funds and structural environment which decide whether the facilities on offer will be successful or not.

Thanks to experimental archaeology, on the one hand it is possible to solve scientific problems, on the other, such experiments or hands-on archaeological demonstrations can bring everyday life in past times closer to a wider audience in an exciting and informative way. Scientific experiments and hands-on archaeology can be the bridges which unite the academic community and interested lay people. This opportunity should definitely be exploited as a chance to promote the future of archaeology to the widest possible audience.

Translated by Sandy Hämmerle.

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17

CROSSING THE BOUNDARIES

Changes in professional archaeology within wetland studies

Stefan Hochuli and Gishan Schaeren

Introduction: professional archaeological research in wetland studies over the past 150 years

1854–1900: pioneers

During the nineteenth century it was mainly members of the educated upper classes with an interest in the arts and cultural history who were concerned with research on lakeside dwellings. These 'universal scholars' were often members of the clergy, teachers, doctors, lawyers or businessmen, some of whom investigated the archaeological sources with very observant eyes and a great amount of expertise. Some collectors, inspired by the 'pile dwelling euphoria', exploited the sites like goldmines and operated a lively antiques trade. The general emphasis was, at that time, placed on collecting as many finds as possible and reconstructing an exotic, nature-loving prehistoric way of life (Figure 17.1). That is the reason why the systematic work carried out by just a small group of researchers cannot be praised enough.

1900–1945: systematization

There were hardly any professionally trained archaeologists in Switzerland until specialization was introduced at the beginning of the twentieth century. The first systematic research projects were now being initiated even though none of the universities had yet established a chair of pre- and protohistory. Several compendia date from that time (e.g. Jakob Heierli, *Urgeschichte der Schweiz* 1901; Karl Keller-Tarnuzzer and Hans Reinerth, *Urgeschichte des Thurgaus* 1925; Otto Tschumi, *Urgeschichte der Schweiz* 1926; Hans Reinerth, *Die jüngere Steinzeit der Schweiz* 1926).

The founding of the Swiss Society of Prehistory and Archaeology (Schweizerische Gesellschaft für Ur- und Frühgeschichte) in 1907, brought into being an archaeological institution which would prove to be a landmark, and not just as a pioneer in the research of wetland settlements. With the introduction of the

Figure 17.1 Like a divine revelation, the ‘pile dweller’. Illustration by August Aeppli from: Meinrad Lienert (1936) *Erzählungen aus der Schweizergeschichte*.

Swiss Civil Code in 1907 the legal responsibilities in relation to archaeological sites were defined. The cantons were now responsible for culture and therefore for archaeological heritage. This principle has not changed and is now embedded in the constitution. In the years between the two World Wars pre- and protohistory became a generally recognized discipline throughout Europe. A number of projects were carried out in that period, e.g. Egolzwil LU-Station 2 (1932/3), Hochdorf LU-Baldegg (1938), Pfyn TG-Breitenloo (1942), Arbon TG-Bleiche (1945), and Zug ZG-Sumpf (1923–37). Groundbreaking archaeological work also took place in neighbouring southern Germany. Excavations of large areas from 1919 to 1928 in the moors of the Federsee, in particular, resulted in the detection of entire Neolithic and Bronze Age villages (e.g. the settlements at Aichbühl, Riedschachen and 'Wasserburg' Buchau).

1945–1960: specialization

Internationally valid methods were applied from the Second World War onwards. The so-called 'Zurich School' of Professor Emil Vogt (a curator and later the head of the Swiss National Museum in Zurich) had a particularly significant influence on research into archaeological pile dwellings. The universities started to specialize in certain periods and at the same time research became more international. Typically, research at that time was shaped by personalities most of whom were responsible not only for excavations and research but also acted as directors of museums and were thus in charge of education. At the same time, specialists in botany, osteology and sedimentology (amongst other fields) were increasingly being called upon to contribute to the research. The economic boom during the decades after the war brought widespread acceptance of archaeological research. Extensive surveys of lakeside settlements – often pure research excavations – were carried out in the 1950s: for example at Thayngen SH-Weier (1950–3), Zug ZG-Sumpf (1952–4), Burgäschisee BE-Station Süd (1952: 1957–8), Egolzwil LU-Station 3 (1950/2) and Station 4 (1954–64).

1960–1974: the boom begins

In many Cantons (Swiss regions) the large construction boom resulted in the establishment of institutionalized archaeological agencies: the cantonal archaeology departments. The impact of the motorway system in particular caused a veritable archaeological 'initial boost' in many places, as the excavation expenses were seen as part of the costs of road construction. The federal government financed the excavations and the cantons were responsible for carrying them out and for preserving, studying and storing the finds.

The wetland settlement studies undertaken during that time could not rely on standardized technical and archaeological methods yet. In many areas experience was still minimal. There was still a great deal of improvisation involved and working conditions were sometimes rather adventurous. The excavation of Auvernier-La Saunerie at Lake Neuchâtel, which started in 1964, is regarded as the first project of contemporary wetland archaeology in Switzerland. Archaeological underwater research on the 'pile dwellings' began around the same time, with the first centre based in Zurich.

From 1974 onwards: the time of major projects

The large excavation of Twann BE at Lake Bienne was significant in many ways, indeed, groundbreaking for future research in Switzerland. An area of approximately 2,400 square metres was excavated from 1974 to 1976. With 50–90 personnel this excavation set new standards as far as organization and administration were concerned. A total of 25 Late Stone Age settlement phases were identified and 22,000 tools made of stone, antler and bone were found. Approximately 200,000 ceramic sherds and several hundred thousand bone fragments were unearthed and *c.* 7,000 wood samples taken. It was the first time that various natural science specialists (e.g. archaeozoology, archaeobotany, sedimentology, dendrochronology) were consistently integrated in a single excavation.

It would not make sense to present in detail each and every large excavation of a wetland settlement that has been carried out since in Switzerland. It is important, however, to note the enormous dimensions of some of these excavations. Most of the areas excavated measured several thousand square metres and the numbers of finds sometimes reached the hundreds of thousands. The following statistics from some of the projects illustrate the huge and almost insurmountable challenges:

- *Zürich ZH-Mozartstrasse*, *Lake Zurich*: 1981/2, *c.* 3,300 square metres excavated, *c.* 60 personnel, six strata comprising a total of *c.* 25 settlement phases (Late Stone Age, Early Bronze Age), 26,900 wooden piles, 2,800 horizontal timbers, 2.6 tons of pottery, *c.* 100,000 bone fragments, 179 kg of botanical samples (59,500 charred, 292,000 uncharred remains).
- *Cortaillod GE*, *Station Est*, *Lake Neuchâtel*: Underwater excavation 1981–4, Late Bronze Age, 20,000 square metres excavated (7,200 square metres systematically excavated).
- *Hauterive NE-Champréveyres*, *Lake Neuchâtel*: 1983–6, 11,100 square metres excavated.
- *Steinhausen ZG-Sennweid*, *Lake Zug*: 1988–91, Late Stone Age, 1,700 square metres excavated area, 1.4 tons of pottery, 1,500 stone tools, 9,000 flint flakes, 3,500 bone and antler tools, 34,000 unmodified bones and antlers.
- *Arbon TG-Station Bleiche 3*, *Lake Constance*: 1983, 1993–5, Late Stone Age, 1,100 square metres excavated area, 8,200 stone artefacts, 550 wooden artefacts, more than a ton of pottery, 2,800 bones, antler tools, 1,400 wooden piles, 1,700 other construction timbers.
- *Concise VD*, *Lake Neuchâtel*: 1996–2000, Late Stone Age/Early Bronze Age, 4,700 square metres excavated area, 8,000 piles (Figure 17.2).

The refinement and systematic application of underwater excavation methods has also developed during the last 25 years. Only now have the extensive remains

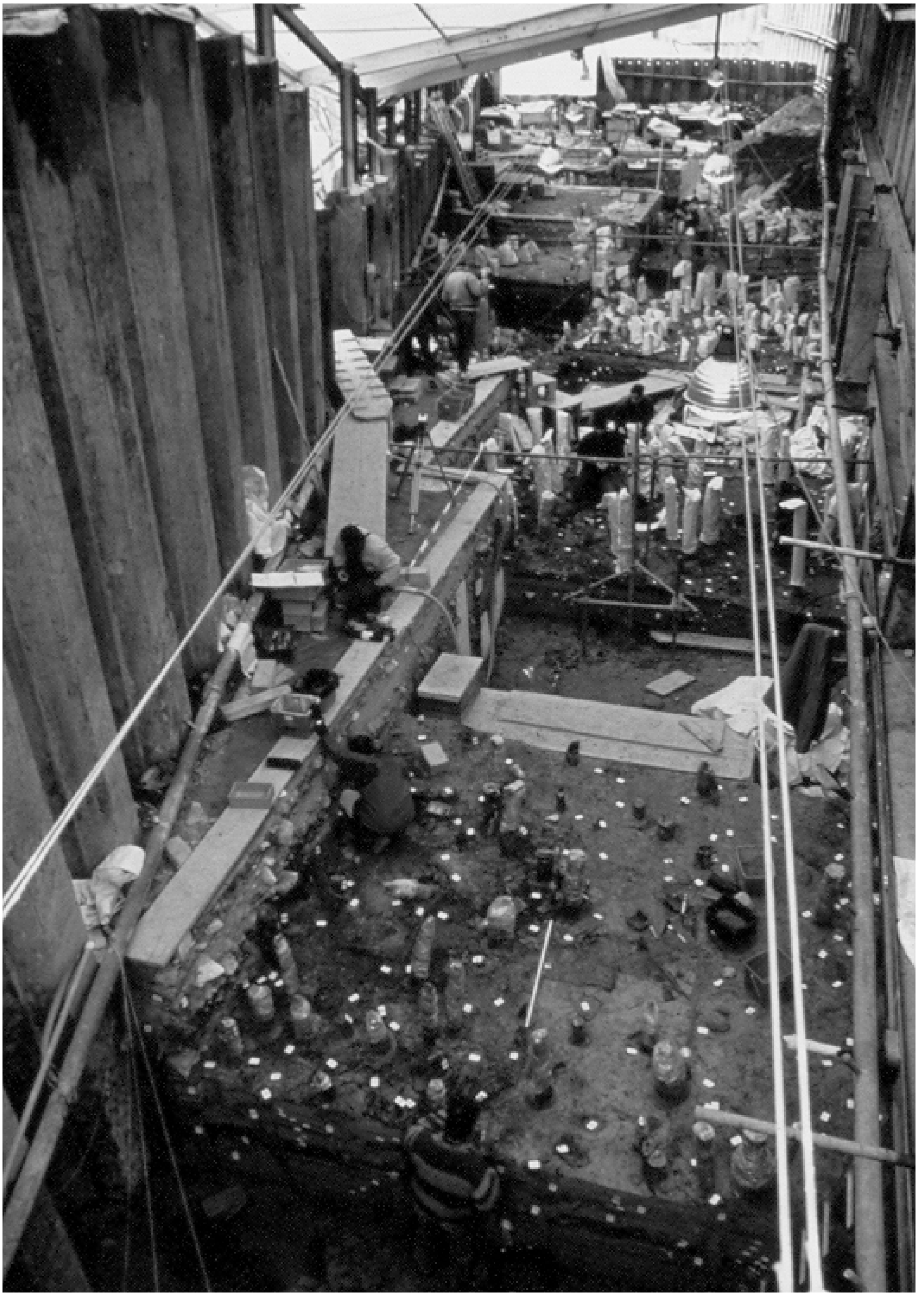

Figure 17.2 One of the last major pile dwelling projects? Between autumn 1995 and spring 2000 the remains of more than 20 overlying Neolithic and Early Bronze Age village phases had to be excavated in Concise at Lake Neuchâtel. Photograph: Archaeology Department of the Canton of Vaud.

of prehistoric cultural layers, lying in the shallows of the lakes, become properly available for research. Several cantons periodically maintained teams of underwater archaeologists. Today, only the cantons of Berne and Zurich still carry out permanent underwater excavations.

Professional archaeology under the spell of the 'pile dwelling problem'

From the beginning ethnographic models were used to interpret lakeside dwellings, thereby first and foremost applying the romantic ideal of the exotic, nature-loving way of life thought to exist among the North American and the South Pacific Island tribes (Keller 1858). The fact that the pile dwellings were mistakenly attributed to the Celts at the time increased the long-standing fascination with the Celts (=Helvetians) and turned it into a veritable 'Celtomania'. The Helvetians and consequently the pile dwellings and their inhabitants became an important identity-founding chapter in the official national history of Switzerland. The response to these discoveries cannot be explained by scientific curiosity alone. It was recognized instantly that these finds contained a common denominator for the history of all parts of the country. Lakeside settlements were now being found everywhere, north and south of the Alps. Finally there was a national history without language problems, without denominational boundaries: a history which brought the Midlands and the mountain regions together (De Capitani 1998).

Apart from this social dimension there came in time, with the discovery of the pile dwellings, various hypotheses on the reconstruction of the remains that had been preserved.

The questions of whether the pile dwellings represented settlements in the water or on land and whether the houses had stood on platforms or not and indeed whether they were even entire settlements were all raised. From 1925 onwards this discussion became more heated. The vehemence with which one theory or another was represented took on a quasi-political dimension, as the spokesmen were either Swiss or German exponents. The 'new' generation of scholars had to prove at any cost that the pile dwellings never existed and the 'pile dwelling myth' was indeed finally 'destroyed' in the 1950s. Even when, in the 1960s and 1970s, new evidence showed that pile dwellings and lakeside dwellings coexisted in harmony, some scholars were not able to face the reality. A good example is the article on the 125 years of pile dwelling research written by Josef Speck in 1981 where he stated:

> If I am not mistaken, the scientific debate on the pile dwelling problem has almost arrived back at the point where it started in the twenties, when the motto was: hither pile-supported beach villages, thither on-shore villages at ground-level, though with one weighty difference. While at the time convinced followers of Keller's idea of permanent lake villages on pile-supported platforms still existed, there is unanimity

> among experts today that one must take one's leave at least of this idea once and for all
>
> (Speck 1981: 135)

It is incredible to see how he does not even consider the unmistakable evidence provided by the site of Thayngen-Weier SH, Switzerland (Stöckli 1979), and that of Fiavé, northern Italy (Perini 1975).

Today, the so-called pile dwelling problem is no longer discussed intensively. The strictly regional orientation of professional archaeology (cantonal archaeology departments) has meant that solving research problems which extend beyond regional boundaries, such as the pile dwelling problem, is often no longer a priority. Thanks to natural sciences, other questions have come to the fore. While chronological and typological problems were still at the centre of research in the 1980s, socio-economic questions are now being posed: how did a settlement develop? What can be said about the economy? What relations with 'abroad' can be shown?

'New' signpost to prehistoric society: rubbish dumps as archives

While federalism made and makes itself felt more and more in professional archaeology, development in the natural sciences, which were called 'auxiliary sciences' for many years, took a somewhat different course. The second pile dwelling report published in 1858 already contains a comprehensive description of the pile dwelling settlements. In it, petrographical, botanical, zoological and other knowledge is woven together to a colourful reconstruction of everyday life. In the third report published in 1860, the zoologist Ludwig Rütimeyer and the botanist Otto Heer speak extensively and in detail of the bone finds and the plant remains respectively. In the following years it was always certain researchers who represented their field of expertise in the area of archaeological research and published their results in general syntheses which were not restricted by regional borders (Furger *et al*. 1998). The rubbish dumps and settlement layers preserved in the ground water over thousands of years were being treated as valuable archives, which could be increasingly vital to the reconstruction of the environment and the economy of prehistoric societies.

From 1930 to 1970 the archaeological forum was dominated, apart from discussions about house construction ('pile dwelling problem'), by questions as to the relative and absolute sequence of the Neolithic and Bronze Age cultures. Compared to the preceding decades, scientific examinations were often carried out, but only in certain instances and in cases of particularly remarkable features.

Dendrochronology as a guideline

The impact of dendrochronology was simply revolutionary in the development of archaeological wetland studies. Although positive results were achieved as early as the 1940s and the method was consistently experimented with and developed from the 1950s onwards it was not until the 1980s that it finally made a breakthrough in archaeology. Dendrochronology and the associated ^{14}C-dating now made it possible, to a large extent, to solve the problems with chronological sequences (Hochuli *et al.* 1998). The dating methods gave all areas of archaeological research a new impetus. Up until that moment, it had been impossible to interpret the accumulation of thousands of piles correctly. Dendrochronology now made it possible to identify certain houses, to recognize the construction history and development of entire villages and to track the settlement dynamic of entire regions with unprecedented chronological precision, sometimes accurate to within a year.

It was also possible to apply the same chronological precision in researching botanical and animal remains, settlement layers and finds. Archaeobiology in particular once again received the attention it deserved.

The challenge of large amounts and good preservation quality

The large excavations undertaken from the 1970s onwards yielded enormous amounts of finds, some of which were very well preserved and resulted in comprehensive documentation of the complex findings. This turned every excavation of a wetland settlement into a large task. In addition to the traditional categories of finds such as ceramics, stone tools, bone and deer antler implements, and large amounts of 'rubbish' (stone, bone, deer antler etc.), scientific samples were now being gathered (Figure 17.3). More and more, the natural sciences were involved in the scientific analyses of the finds: geoarchaeology (sedimentology, micromorphology), archaeobotany, pollen analysis, archaeozoology, malacology, dendrochronology, anthropology, and ^{14}C-analysis.

Nowadays there is a very close interdisciplinary co-operation between many universities and archaeological government departments, in order to examine the almost inexhaustible amounts of botanical and zoological macrofossils that have been preserved over thousands of years in the waterlogged deposits of the wetland settlements.

Protagonists of pile dwelling archaeology in the various Swiss cantons

Archaeology has strong regional roots. This is probably the main reason why the Constitution of the Swiss Confederation dictates that the 26 cantons are responsible for the field of culture and the protection of nature and of cultural heritage (Constitution § 69 and 78). Therefore, Swiss archaeological heritage is cared for and researched by the cantons. The rights of ownership regarding the archaeological finds are also clearly regulated. According to the Swiss Civil Code archaeological finds belong to the canton in which they were found (§ 724).

Because of this federalist regulation there is a different legal situation in each canton, which in turn must be considered in the light of their individual

Figure 17.3 Tens of thousands of bones! The archaeobiological analyses are labour-intensive, but they provide a lot of information on the natural way of life and the survival strategies of early humans. Photograph University Basel, Seminar für Urgeschichte, Archäobiologie.

cultural, political, historical and economic backgrounds. Hence, the legal basis for archaeology in general and wetland archaeology in particular varies strongly in Switzerland. It may be stated, however, that the legal protection of the archaeological heritage is generally well developed in most cantons. Regulations as to the preservation, conservation and research of the archaeological cultural assets by cantonal archaeological departments, museums and collections exist practically everywhere. It is also considered important that efforts are made to create, promote and develop knowledge and understanding of the significance of cultural heritage. Cultural assets that are deemed worth protecting are recorded in inventories in many places. The application, however, of the relevant regulations in various places leaves a great deal to be desired.

Due to the fact that the cantons are responsible for archaeological research, archaeology is bound by territory and sovereignty. The operational level is strictly limited to the cantons. Since the 1960s expert archaeological agencies have been established in most cantons: the cantonal archaeology departments. Because of the large building development boom some of these have developed a great deal over the past 30 years. These days, they usually operate independently of museums and universities and have largely replaced both as far as excavating is concerned. Some cantons, however, even today do not have an established archaeology department, although this is called for by the Malta Convention

(European Convention for the Protection of the Archaeological Heritage of Europe), which Switzerland has also ratified. The 'cantonalization' of archaeology results in extreme differences in professionalism within short geographical distances. The canton of Zurich, for instance, is financially well provided for and has a considerable number of personnel available (with its university, its cantonal archaeology department and a Municipal archaeology department).

The role of the federal government

Despite their cultural sovereignty, the federal government supports the cantons with considerable funds. In 1993, for instance, almost 50 per cent of the expenditure of the cantonal archaeology departments came from the federal government, and of that, motorway funds with approximately 28 per cent made up the largest share. Up to now, 'motorway monies' of around 400 million Swiss Francs (about €270 million) have been spent on archaeology. A large part of these funds has been used for researching prehistoric lakeside settlements. Had it not been for this extensive federal funding, current knowledge on Swiss pile dwellings would be significantly limited. This substantial support is based on a decision of the Federal Council in 1961 to regard the costs of excavations in connection with the national roads (motorways) as part of the expenditure for their construction (Weidmann 1998).

Further annual contributions towards the conservation and research of wetland sites are made available by the Federal Office of Cultural Affairs (Bundesamt für Kultur – BAK) and the Swiss National Science Foundation (Schweizerischer Nationalfonds zur Förderung der wissenschaftlichen Forschung – SNF).

Universities

Even though it was universally accepted that scientific research was really a matter for university departments, this task gradually shifted to the cantons. This development has come about mainly due to the fact that there are more funds available to the cantonal archaeology departments than to the universities. This, however, contradicts the reality that quite a few cantonal archaeology departments do not, in fact, have an explicit research assignment – unlike the universities. Besides which, the archaeological officials are kept very busy with rescue excavations, another reason why one must not expect consistency in research. Research is thus undertaken rather randomly, mainly from rescue site to rescue site.

On the other hand, intensive and successful co-operation between cantonal archaeology departments and certain university departments sometimes does occur. In cases where cantonal funds were given to universities in connection with research assignments, certain university departments were able to build up the infrastructure necessary and carry out significant research (especially archaeobiology). Quite a number of MA or PhD candidates carrying out their research at universities are funded by cantonal archaeology departments.

Swiss Society of Prehistory and Archaeology

The Swiss Society of Prehistory and Archaeology (SSPA) stands like a lighthouse of 'national archaeology' in the 'federalist sea' composed of the cantonal archaeology departments. It is the only institution so far that has in some cases managed to bridge the federalist fragmentation of the archaeological landscape in some cases and continues to do so. Amongst other things, the society has for years, taken on the task of doing research syntheses, which were oriented thematically or which related to more than one region. Between 1958 and 1965, it published the *Materialhefte zur Ur- und Frühgeschichte der Schweiz* (Reports on prehistory and protohistory in Switzerland). These were followed by the six volumes of the series *Ur- und frühgeschichtliche Archäologie der Schweiz/UFAS* (Pre- and protohistorical archaeology in Switzerland). Finally the series *Die Schweiz vom Paläolithikum bis zum frühen Mittelalter/SPM* (Switzerland from the Palaeolithic to the Early Middle Ages) has been running since 1993. The society also plays an important mediating role between archaeological professionals on one hand, and archaeologically interested laypeople on the other.

Museums

Of course, the *c.* 100 cantonal, communal and private museums that have archaeological collections also play an important role. They are of major significance in terms of collecting, conserving, restoring, inventorying and displaying finds. Research on wetland archaeological topics that is carried out in museums however, is rather modest compared to the time before cantonal archaeology departments came into being. The Swiss Confederation also owns an excellent collection of archaeological finds dating from all periods, recorded in an up-to-date manner in the Swiss National Museum in Zurich, which was founded in 1898. The significance of this museum for wetland settlement research, has however, decreased to a large extent over the past years. The cultural sovereignty of the cantons has also meant that the museum practically stopped carrying out excavations and there have been no research activities worth mentioning. The museum is, however, still a leader in the field of conservation of waterlogged timbers.

Commercial archaeologists

Early pile dwelling research was often carried out by well-to-do 'private scholars'. As time went on, the preservation and research of archaeological sites established itself as the responsibility of the state. Nowadays, by no means all the excavations are carried out by archaeologists in civil service. Quite a number of cantons have turned to private archaeology companies to whom they subcontract excavations. Whilst this 'privatization' of archaeology does not necessarily lead to problems, various examples of quarrels over competence and copyright and also conflicts about employment and contract law show, however, that the out-sourcing of a state responsibility can quite easily cause serious difficulties.

Laypeople

A further controversial topic is the involvement of private collectors and enthusiasts in professional archaeology. Experience has shown that the work of private treasure hunters can have catastrophic consequences (especially when metal detectors are used). Treasure hunters rummage through archaeological sites regardless of scientific problems, thereby destroying layers and building structures and carelessly discarding pieces that are of no obvious significance. Sometimes enormous damage is done to archaeological sites in this way. That is why the involvement of private laypeople pursuing such activities invokes a reaction of virtually automatic rejection in many experts. Several examples, however, show that involving honorary personnel can mean useful and substantial support in certain cases.

Looking to the future: things will quieten down

Pile dwelling research today seems to be standing on the threshold of a new phase: the aftermath of the numerous large projects. As the construction of the large road and railway facilities will soon come to an end, large pile dwelling projects will become rarer. Those prehistoric villages that are situated in the shallows of the lakes and are therefore threatened by erosion, as well as those remains that are affected by certain building projects, will be the only objects of large rescue excavations.

Where is the national research strategy?

While building up and extending the funds and personnel of the cantonal archaeology departments led to a great professionalization of archaeology, research on the other hand became geographically more limited, as the cantonal archaeology departments were only allowed to excavate their own soil. Additionally, it was the preserve of the university lecturers to decide which period or region they wanted to turn their main research focus on. While a great deal of research is carried out in Switzerland, there is no coordination on a national level. Research projects that deal with national research problems and which cover more than one canton are difficult to finance. Not even the expert organization Arbeitsgemeinschaft für die Urgeschichtsforschung in der Schweiz/AGUS (Working group on prehistoric research in Switzerland), which only accepts members with a university degree, has managed to bridge this gap yet.

To compound matters, research at universities, in the area of archaeological sciences is always supported and characterized by individuals and not by institutions. In cases where lecturers leave or the main research focuses of faculties change, there is a danger of existing knowledge and involved structures being lost. It is only with a nationally guided research strategy that this lack of constancy in research and teaching could be absorbed. However, one can assume that in the end, because of the 'general lethargy', everything will stay as it is.

Conclusions

'Product archaeology'

Today, archaeology exists in an ambivalent social and political environment. On the one hand archaeological topics receive a lot of attention; there is regular media coverage of exciting archaeological discoveries. On the other hand, the financial everyday reality of archaeology is affected by large government budget deficits and the ever-growing political call for a decrease in the state quota (Figure 17.4). More and more cutbacks have to be made in archaeology too; because the struggle for public funds has become more hard-fought than ever before. Archaeologists are increasingly being forced to defend themselves, their projects and researches. Appropriate recognition, however, will no longer be obtained merely on account of highly qualified research. Archaeologists find themselves forced more and more to develop a marketing strategy for 'product archaeology'. Archaeologists who still only refer to their statutory mandate are having a hard time gaining public recognition. In the long run archaeology will only survive if we manage to convince the public and the politicians of its right

Figure 17.4 Wetland studies cost money! Carrying out large rescue excavations and managing the enormous amounts of finds and documentation requires extensive funding, often millions. Photograph Res Eichenberger, Archaeology Department of the Canton of Zug.

to exist, that is, if we manage to convey its research results in a popular manner. This will not only cost money, it will necessitate a strong commitment and a professional approach and appearance.

Nowadays wetland settlement research is no longer carried out by 'research personalities' but by teams. This, however, does not mean that outstanding researchers no longer exist. Despite the use of state-of-the-art technical aids, future research on prehistoric wetland settlements will still depend on personalities whose pioneering spirit will make them equal in every way to the first 'pile dwelling' researchers of the nineteenth century.

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CONCLUSIONS

THE IMPORTANCE OF LAKE-DWELLINGS IN EUROPEAN PREHISTORY

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The literature of archaeology abounds with words which were invented during a few decades of the nineteenth century, and today sound curiously archaic. 'Shell-middens' (from the Danish *Kjøkkenmødinger* or 'kitchen middens'), 'hillforts', 'barrows', and 'lake-villages' or 'pile-dwellings' all survive as technical terms (in English and usually with equivalent terms in other European languages) to confuse both archaeologists and public alike. The very archaism of these terms, however, reflects the importance of such phenomena in the emergence of a consciousness of European prehistory, and their historic contribution to the development of an archaeological science. Pile dwellings in particular had a critical role in stimulating Europe's imagination about its prehistoric past. Consider the following passage, from a book published in 1863:

> In the shallow parts of many Swiss lakes, where there is a depth of no more than from 5 to 15 feet of water, ancient wooden piles are observed at the bottom sometimes worn down to the surface of the mud, sometimes projecting slightly above it. These have evidently once supported villages, nearly all of them of unknown date, but the most ancient of which certainly belonged to the age of stone, for hundreds of implements resembling those of the Danish shell-mounds and peat-mosses have been dredged up from the mud into which the piles were driven.
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> The Swiss lake-dwellings seem first to have attracted attention during the dry winter of 1853–54, when the lakes and rivers sank lower than had ever been previously known, and when the inhabitants of Meilen, on the Lake of Zurich, resolved to raise the level of some ground and turn it into land, by throwing mud upon it obtained by dredging in the adjoining shallow water. During these dredging operations they discovered a number of wooden piles deeply driven into the bed of the lake, and among them a great many hammers, axes, celts, and other instruments. All these belonged to the stone period with two exceptions, namely, an armlet of thin brass wire, and a small bronze hatchet.
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> (Lyell 1863: 39–40)

The book is not some antiquarian tome of local interest, nor yet a guide for English tourists visiting the Alps; instead, it is one of the most controversial books of its age, at the cutting-edge of nineteenth-century science. It is Sir Charles Lyell's *Antiquity of Man*, published only four years after Darwin's *Origin of Species* and pressing home the logic of the new vision of an evolutionary history of the human species, reaching back into geological time. The recession of Lake Zurich, and its revelation of 'an ancient Lacustrine or Lake-dwelling population', could not have happened at a more fortunate time, for it fuelled the imagination of European science at a critical point in the emergence of a new view of the past, at a time when Boucher de Perthes was collecting handaxes from the gravels of the Somme, and in far-off Borneo Alfred Russel Wallace was penning the manuscript which would belatedly precipitate Darwin into writing a summary of his own ideas. The publication of Darwin's book in 1859, in the same year that Sir John Evans and Sir Joseph Prestwich reported on the discoveries in France, caused the dispute over human origins to irrupt from antiquarianism into popular consciousness. The picture of the Swiss pile-dwellers provided an image of a primitive European past comparable to the tribes being described overseas, and from which the European nations had themselves evolved – supporting a naturalistic view of human origins and development. At the same time, they provided a wealth of detail about past conditions, illuminating both the way of life of these early European populations and the environment and resources on which they depended. Darwin himself quoted extensively from faunal and botanical studies on the lake-dwellings in his *Variation of Animals and Plants under Domestication* of 1868, citing the work of Adolphe Morlot, Ludwig Rütimeyer (with whom he was in direct contact) and Oswald Heer. The Alpine lakes were at the forefront of archaeological and scientific attention, in the decade in which the very word 'prehistory' came into being. Sir John Lubbock (later Lord Avebury, and inventor of another novel term, 'Neolithic') devoted a full chapter of his 1865 book *Prehistoric Times* to a description of the Alpine evidence, and even became involved in an unseemly dispute with Lyell over whether the latter had obtained his information about lake-dwellings and kitchen-middens directly from reading the work of Adolphe Morlot, or from reading one of Lubbock's articles on it (Wilson 2002). That an altercation on this matter – leading even to threats of legal action – should break out in the immediate circle of Charles Darwin's closest friends and associates shows how central these topics in European prehistory were to the critical issues of Victorian science (Sherratt 2002).

Contemplating the present-day scene, however, it is hard to avoid the conclusion that we have become complacent about the lake-dwellings, and that by the twenty-first century they have become rather taken for granted. While they are certainly the object of sustained investigation, on an almost industrial scale, they are no longer the battle-ground of evolutionary theory or the subject of headlines in the scientific press. A glance at the shelves of a good archaeological library will reveal the enormous weight of scholarship which has accumulated in the intervening century and a half since the enthusiasm of those initial reports. In the tall format of European A4 paper (usually of exceptional weight and quality to match the meticulously drawn illustrations), row after row of monographs testify to the sustained investment of money and time which has been devoted to their investigation. Whether in German, French, Italian or Slovenian – and nowadays usually with very extensive English summaries or even parallel text – an outstanding body of evidence is matched by an outstanding quality of publication. This encompasses not just the sites (both above and below water) and their geological settings, their stratigraphy and their artefacts; it involves the evidence of those disciplines which in no small part emerged directly from the pioneer nineteenth-century scientific engagement with this abundance of material, disciplines such as palaeobotanical research, which followed in the footsteps of Oswald Heer but now extended to a microscopic level of pollen-grains, phytoliths and diatoms, and the astonishing precision of dating made possible by dendrochronology. No one can say that lake-dwellings are not taken seriously, at least at the level of primary recovery and publication. But it is precisely the discrepancy between so much information and the relative lack of excitement in the archaeological and scientific community at large about this veritable treasure-house of knowledge concerning the peoples of central Europe some three to six thousand years ago which leads to the impression of complacency; and it is the challenge to present-day researchers in this field to re-kindle the excitement which followed their first discovery.

The lake-dwellings were important in another context, too, during the later nineteenth century, especially for the Swiss. While the Helvetic Confederation went back to the Middle Ages, Switzerland as a nation-state emerged only in 1848, after a decade of what was effectively a civil war (the Sonderbundskrieg). 'Both at home and abroad, the Swiss of different cantons will henceforth be perceived and act as members of a single nation' as the *Neue Zürcher Zeitung* proclaimed in September 1848 (cited in Zimmer 2003: 119). It was therefore a special bonus for the nation-builders that in the probings which followed the low levels of Lake Zurich some six years later, the 'ancient Lacustrine population' was found to have inhabited practically every lake in Switzerland: a perfect 'common ancestor' for cantons which had come to be divided not merely by their three major languages but by the different political visions that had found expression in the Sonderbundskrieg. The lake villages thus achieved a special prominence in the land of their discovery, not just as antiquarian curiosities or even as materials of immense value to science, but also as a powerful symbol of national unity and identity (Kaeser 2004). Peaceful, at one with nature, living an idyllic existence which combined farming, hunting and fishing in a harmonious manner in a spectacular scenic setting – it is not surprising that the discovery of the lake-villages evoked an outpouring of romantic representations of prehistoric life, perhaps the single most extended exercise in the imaginative re-creation of Neolithic communities anywhere in the world, certainly the only one to give rise to a distinctive genre of oil-paintings (see, for example, many luscious illustrations in Louboutin 1990). While north-German megaliths had inspired an earlier generation of romantic artists (like Caspar David Friedrich's *Hünengrab im*

Schnee of 1807, now in the Staatliche Gemäldesammlung in Dresden), these skeletal stone monuments appeared as the remains of a remote and scarcely imaginable past (even if in reality, as we now know, they were coeval with the lake villages). The immediate impact of the Swiss discoveries and their representation in art lay precisely in their domestic architecture and the detail of pots and everyday objects, and the sheer believability of the scenes which were conjured up to re-populate the pile-dwellings, complete with revealing maidens and fur-clad huntsmen bringing home their prey. This was a homely and innocent past with which not only the circum-Alpine peoples but also the inhabitants of Europe as a whole could identify.

This combination of the universal and the particular, as Marc-Antoine Kaeser points out (2004), is the source of the peculiar appeal of the circum-Alpine lake villages: on the one hand as a specific manifestation of human ingenuity, and at the same time as exemplars of a phase of human development – the *époque Robenhausienne* as it was called in Gabriel de Mortillet's geologically inspired cultural succession (as successor to the Magdalenian, which still survives in archaeological terminology). The term Robenhausien was taken from a classic lakeside settlement-site on the Pfäffikersee near Robenhausen, some 15 km east of Zurich, excavated by Jakob Messikommer whose eponymous oak tree still stands there today within a delightful nature reserve. The individual, context-specific qualities which inspire the Romantic imagination are thus intimately mixed with the general properties of an unusually well-preserved sample of Neolithic behaviour, which invites scientific investigation in the tradition of the Enlightenment (Sherratt 1996). Both aspects of lake-villages deserve our attention.

Let us take them in turn; and first, the specificity of lake-dwellings. Those classic nineteenth-century terms (shell-middens, lake villages, megaliths, tells etc.) are the names of archaeological *phenomena*, not general classes or examples of universal categories. When monuments describable as 'megaliths' were discovered in different parts of the world, it was first assumed that they tracked the wanderings of some specific people; when this was shown to be implausible, it was tempting to find some general set of conditions whose coincidence would explain megalith-building behaviour. In reality, however, there are so many such conditions – tolerance of unfinished surfaces, the desire to use natural metaphors of weight and permanence, the existence of wooden houses as models of covered space, the need for monumental tombs – that it is quite impossible to write a universal formula (in the way in which some New Archaeologists tried to find material manifestations of 'the state', for instance, which would allow them to write a series of equations between behaviour and material conditions). Megalith-building is a tradition (or rather a series of traditions), which can be illuminated by tracing genealogies: were *these* megalithic monuments related to *those* megalithic monuments (Joussaume 1985)? How do those of the Caucasus relate to their contemporaries in the Paris basin? Or, more puzzlingly, those of the Golan Heights, also more or less contemporary? These offer genuine ambiguities of interpretation, but the notion of affiliation is a meaningful one; whereas the Iron Age examples of southern India, or even of Thrace, have no connection with each other or with earlier monuments, and the concept of genealogy is unhelpful. This quality of ambiguity between genealogy and parallelism is characteristic of all the classic archaeological phenomena: clearly shell-middens accumulate on coasts, where shellfish provide both food and abundant inedible remains – but was there not some specific community of practice and common understanding in Late Mesolithic Europe in using these accumulations to mark the positions of long-occupied settlements and winter gathering-places, which is more than mere mechanical coincidence in similar circumstances? 'Pile-dwellings', too, have both a global and a European occurrence – the former illuminatingly investigated by Pierre Pétrequin (1984), in quest of ethnographic illustration – but not an identity of origin. The use of a particular architectural technique and form has its own practical logic in certain environmental conditions, but equally forms a series of local traditions of construction, with specific historical conditions of genesis and spread.

If we apply this mode of thinking to types of Neolithic settlement-sites, what is the result? The first, and classic, mode of Neolithic settlement was the *tell*: the accumulated settlement-mound resulting from the use of mud to create dwelling-units in compact villages occupied over many generations. This was the outcome of a certain mode of life and concept of land occupance, and the employment of a particular set of constructional techniques, whose combination gave rise to a characteristic and highly recognizable archaeological phenomenon. The use of mud as a constructional material had a practical logic in the climatic and edaphic conditions of the Near East, and the tendency of mud-built structures to accumulate into conspicuous mounds was desirable both on ecological grounds (positions near springs or lakes, with a tendency to flood) and no doubt also on ideological grounds (to emphasize longevity, elevation, ancestry, etc.). The tell as a historical phenomenon thus had a definable area of origin, and spread with farming itself; though (especially where indigenous populations were incorporated, as in the Carpathian Basin) its adoption might be preceded by less aggregated forms of 'flat' settlement, and moreover it did not survive there as a settlement-form as long as it did in the Balkans and Near East. In fact it spread only as far as eastern Hungary, though its form may have some echo in the concentric-ditched ritual structure of western Hungary and adjacent areas known as a *Rondelle* or *Kreisgrabenanlage* (Kaufmann 1997) which repeats the circular shape of the tell as an abstracted element within a more scattered grouping of longhouses. Thus what arguably began as a consequence of the adoption of a particular building-material (mudbrick) ended up as a symbol of community and identity with a meaning in its own right. As farming settlement moved westward into Europe, changes in constructional technique took place to fit the buildings for wetter environments. The mudbrick and *pisé* constructions of central Anatolia gave way to mud-and-timber construction in western Anatolia and the Balkans, and these in turn to the timber-skeleton and mud-daubed wattlework of central and western Europe – and at the same time the houses themselves became longer in the loess region than in the Balkans, perhaps with provision for stalled livestock. The creation of settlement-mounds ceased when it reached a social and ecological limit. However, tell-like phenomena might again come into existence in specific circumstances beyond these Neolithic limits, such as the type of mounded Iron Age village-settlement around the North Sea known variously in North Germanic languages as *terp*, *werp*, *varp*, *werft*, *wurft* or *wierde*, where the advantage of height and concentration of population encouraged accumulation of deposits even though the timber-based building-technique did not generally have this effect, and the mounds were built up artificially rather than as a consequence of successive house-constructions.

Like tell-settlements, lake-villages are a historical phenomenon with a definable area of genesis and a finite existence as a settlement-type, even though analogous forms of settlement were generated at different times beyond this area. Like shell-middens on coasts, lake-villages require lakes. While tell-settlements typically occur alongside springs or in formerly wet places, mud-construction is not very practical at the edge of a permanent lake with fluctuating water-levels, which would rapidly erode a tell, and few tells directly adjoin lakes. In the few cases where earlier Neolithic settlements occupy lakeside locations, as at Dispilio (Kastoria) in Greek Macedonia in the mid-sixth millennium BC (Hourmouziades 1996), most of the construction is in timber, producing something like a lake-village. Lakeside occupation in this region only became common, however, in the Bronze Age, with sites like Ploca Micov Grad near the Gradište peninsula on the eastern shore of Lake Ohrid in the former Jugoslav Republic of Macedonia. Meanwhile, the lake-village as a cultural form had been pioneered in the circum-Alpine region, with the creation of the classic Neolithic 'pile-dwelling' settlement type. The immediate building tradition from which it was derived was the *Bandkeramik* longhouse tradition of the loesslands, in the phase of Lengyel and Roessen: a timber-based technique in which the uprights were bedded in substantial postholes – easy to dig in a loessic soil. Within the morainic landscapes of the Alpenvorland, however, the clay subsoil of the extensive surfaces was hard to dig with antler picks and wooden shovels, and the reed-swamps around the lakes offered an easier possibility: to drive the timbers directly into the soft mud in the form of piles. Settlements thus proliferated around the margins of the lakes themselves, where organic deposits provided a suitable substrate for building, and the lakeside location gave access both to the wild resources of the lake and fertile horticultural soils on the alluvial fans of influent rivers (pile-dwellings also appeared at this time at Varna in Bulgaria, on an inlet of the Black Sea, complementing the spectacular cemetery – perhaps indicating a Chalcolithic port). The combination of driven piles and wooden flooring and wall-construction created a new and distinctive form of architecture and settlement, just as mudbrick construction had produced the tell: at once a building technique and a way of life, a symbol of community. The lake-village thus became a cultural phenomenon rather than simply an adventitious architectural innovation. That is why it is possible to distinguish between the settlements of displaced lake-dwellers and the settlements of terrestrial populations, when the habitable margins of the lakes were flooded in the Middle Bronze Age and both groups were forced to occupy geologically similar terrain (Menotti 2003a). Like the tell, the lake-village had a definable area of origin and spread: in the

Neolithic being largely confined to the circum-Alpine area, in the Bronze Age spreading more widely (especially along rivers, important for trade), and in the Iron Age becoming very widespread and taking a number of forms – like the crannogs of Scotland and Ireland, the timber fortresses of Biskupin type in the central Polish lakelands or the great river-port of Poggiomarino in Campagna, predecessor of Pompeii – which were often motivated by the need for defence (Menotti 2003b). All of these might be described as 'pile-dwellings', while the Bronze Age riverside mounds along the Danube in western Hungary (like Nagyrev – 'great port') might even be seen as hybrids between lake-villages and tells! Paradoxically, however (and in contrast to the history of the tell-building phenomenon) the practice of building lake-dwellings was abandoned at the beginning of the Iron Age in precisely those areas where it had first begun – perhaps because of the more extensive occupation of the clay-lands, which took population away from the narrow lakeside strips.

The settlement form which distinguished the circum-Alpine Neolithic, therefore, should be seen to be as much a cultural creation as the more obviously 'un-natural' constructions which characterized contemporary Neolithic cultures on the coastlands and plains of northern and western Europe – the burial monuments of earth, timber and stone which include long-mounds and megalithic passage graves. These ritualized houses – most clearly so in the case of the long-mounds, which derive from the loessland longhouse tradition, in parallel with the real houses of the Alpine lakelands – acted as communal foci and symbolic resources. These other characteristic cultural phenomena of the Neolithic serve to remind us that dwelling-houses – whether in tells or lake-villages – were not just *machines à habiter* ('machines for living in', in Le Corbusier's famous phrase), but also themselves vehicles of ritual expression and belief. The 'lake-village' was thus a total cultural creation, as well as a rational solution to the Neolithic occupance of the areas around the Alps.

This excursion into the peculiarity and cultural uniqueness of the lake-dwellings allows us to answer a pressing question from the scientific side: can we treat the evidence of these well-preserved Neolithic settlements as typical, or were they simply an oddity of a mountain and lakeland environment, which would make it dangerous to extrapolate conclusions to anywhere beyond the circum-Alpine area itself? Well: they were certainly a particular local expression of a broader Neolithic tradition of settlement – but then so were the Balkan tells, the longhouse villages of the loesslands, and the megalith-centred hamlets of outer Europe. Each one was peculiar to its own area, and lakeside settlement was the normal *habitus* of the region, not the way of life of some set of marginal marsh-dwellers. (After all, Old World civilization began in Sumer, another famous marshland habitat: the equation of marsh-dwelling with marginality is very much a creation of later city-dwelling populations, and indeed its escapist alterity was a great part of the appeal of the image of the lake-dwellers to the urban sophisticates of the mid-nineteenth century.) There is no obstacle, then, to the scientific investigation of the unique archaeological inheritance of the circum-Alpine region: it will not unduly bias our perception of life in Neolithic

Europe – on the contrary, it will enormously enrich it by its abundance of detail and the variety of its evidence. Who would dig by choice on an eroded land-surface where only the bases of the post-holes are preserved and the living-surfaces have completely disappeared, to uncover the bare outline of a Neolithic longhouse, when it is possible to uncover an entire Neolithic room, with not only the artefacts of its human inhabitants in position on the floor, but also the droppings of the animals and even the pupae of the flies which bred in them? Who could be satisfied by a rough structural sequence of Phases 1, 2 and 3 (a relative ordering of units of uncertain length) when they have become used to noting, say, that an extension had been added to House 5 in the spring of 3752 BC? This is a new and different world, where the precision of prehistoric archaeology out-performs that of classical archaeology, and even of much of Egyptology. Science and art converge when it becomes possible to construct a narrative on the timescale of an individual human life, and when changes can be so precisely fixed in time that we can call them events, and think of how they were actually experienced: the methodology of Collingwood made possible in a dendrochronological laboratory! What a paradox, that archaeological science makes possible an anthropology of the past more comparable to the close observation and understanding of Malinowski than to the homogenized stadial succession of the evolutionists!

What all this adds up to is the opportunity for a fully integrated archaeology, combining analysis and empathy because the imagination can be carefully controlled by detailed observation and forensic examination (Pétrequin and Pétrequin 1988). We can correct the images of Neolithic life shown in nineteenth-century oil-paintings because in the intervening century and a half there has been a steady accumulation of information about the things represented there. Darwin's informants do not lack successors: the intellectual descendents of Rütimeyer and Heer are represented in the pages of this volume, together with the present-day equivalents of Morlot and Messikommer. What is perhaps missing is the artistic imagination. It is the integration of this quantity and diversity of information in terms of human experience and action which is the most necessary element of the nineteenth-century appreciation that is lacking today. We must learn again the art (and discipline) of painting on a broad canvas – literally, perhaps, as much as metaphorically – and recapture the excitement of the pioneer discoveries, while making use of what we have learned in the meantime. The lake-villages of Europe are a unique resource, and in another 150 years few will remain unless they are artificially preserved. They are a precious inheritance, and European archaeologists as a whole – indeed archaeologists worldwide – must be grateful to those whose meticulous work continues to bring them to light.

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INDEX