The Holocene

On-site data cast doubts on the hypothesis of shifting cultivation in the Late Neolithic (c. 4300–2400 cal. BC). Landscape management as an alternative paradigm

Journal:	*The Holocene*
Manuscript ID	HOL-15-0147.R1
Manuscript Type:	Review
Date Submitted by the Author:	n/a
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opium-poppy (Papaver somniferum). Cycles of landscape use are traceable, including coppicing and moving around the landscape with animal herds. Archaeobiological studies further indicate also that hunting and gathering were an important component and that the landscape was manipulated accordingly. Late Neolithic land-use systems also included the use of fire as a tool for opening up the landscape. Here we argue that bringing together all the types of palaeoenvironmental proxies in an integrative way allows us to draw a more comprehensive and reliable picture of the land-use systems in the Late Neolithic than had been reconstructed previously largely on the basis of off-site data.

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Keywords

Central Europe, wetland settlements, archaeobotany, archaeozoology, type of farming, niche construction, use of fire

Introduction

The main purpose of this article is to contribute to a long-standing and ongoing debate on the type of land use in the Late Neolithic (LN hereafter; c. 4300–2400 cal. BC; Figure OSM 1) in the regions bordering the Alps (Figure 1). There are generally two extreme positions, which can be summarized as ‘permanently cultivated plots' *versus* 'shifting cultivation' models. The first hypothesis is based on archaeobiological on-site-data (for definitions see Jacomet, 2007a) and ethnographic sources, the second rests to a large degree on off-site data, but also experimental work. Whereas off-site evidence is primarily based on pollen and micro-charcoal, on-site evidence relies on archaeobotanical and isotope analyses of a whole range of materials, notably botanical macro- and micro-remains, especially weeds and crops, archaeozoological remains and animal dung, as well as wood remains (for a more thorough description of the evidence and citations, see OSM text, chapter 'State of research and interpretation tools)'.

For many years various researchers have stated that empirical on-site data suggest that slash-and-burn cultivation was not practised (at least not regularly) during the LN in the alpine foreland (see e.g. Brombacher and Jacomet, 1997, p. 270 f.; Hosch and Jacomet, 2004, p. 128 ff.). They favour the idea of a sophisticated landscape management, which also included the use of fire. Fields, once cleared, are thought to have been used relatively permanently and worked intensively, and this included weeding and perhaps even manuring. Yet the idea of shifting cultivation is surprisingly resilient, despite much empirical data against it. The main reason for this is that the more marginal landscapes, including the hilly and mountainous areas of the Alps themselves and the regions bordering them, are considered as less amenable to agriculture, for reasons related to climate and/or poorer soil quality (Schier, 2009; Kreuz et al., 2014). This is seen in contrast to Early and partly Middle Neolithic settlement areas (*Altsiedellandschaften*), which were established from 5500 cal. BC onwards on the most fertile loess soils of Central Europe (see Kreuz, 2012) where slash-and-burn is thought to have been unnecessary because the natural soil fertility was high enough. The alpine areas are thought to have been settled only relatively late (after around 4400 cal. BC) by agro-pastoral communities and the only option to farm in such landscapes would have been shifting cultivation (see the so called 'tertiary neolithisation' or '*tertiäre Neolithisierung*' after Schier, 2009, p. 19 ff.). Recently however, systematic surveys have illustrated that the prealpine midlands of France and Switzerland were settled by Middle Neolithic communities from 4800 cal. BC onwards (Boisaubert et al, 2001; Ebersbach et al., 2012; Kreuz et al., 2014; Martin, 2014; Martin, 2015).

<INSERT FIGURE 1>

In this article we undertake for the first time a comprehensive and critical comparison of the two types of palaeoenvironmental data (Figure 2) for the central European lake-dwelling area, which should enable us to assess which of the two existing hypotheses are the more plausible or probable. We discuss methodological problems and combine the existing evidence in order to present an integrative new view of LN human-animal-environmental interactions. The prealpine environments of Central Europe are probably the world's best location for such an attempt. Here, in the last 30 years or so a large amount of high-resolution on- and off-site-data have been gathered and studied (for details see OSM text chapters 'State of research and interpretation tools' and 'Results of on-site data: Basic aspects of animal and plant husbandry'). Indeed the presence of many lakes of glacial origin, which offer excellent preservation conditions, make the region eminently suitable for both types of investigations. During the LN, the so-called 'pile dwellings' on lakeshores and in bogs were in existence (Suter et al., 2009) and these have left some of the best preserved on-site-evidence worldwide. This is underlined by the fact that they were designated as UNESCO World Cultural Heritage sites in 2011 (www.palafittes.org; Menotti and O'Sullivan, 2013; see Figures 3 and 4). The region considered here may therefore also serve as a model region for both integrative archaeological research and earth system studies in the timeframe and region under study.

<INSERT FIGURE 2>

Shifiting cultivation *versus* intensive garden cultivation: state of the art

Here we shall address the two systems under review but refer readers to our more detailed overview of the state of research and interpretation tools available in the OSM chapters ‘State of research and interpretation tools’ and ‘Results of on-site-data’. Although the main topic of this article is agrarian activities, these cannot be understood without looking at the subsistence economy system as a whole, especially if the research agenda includes reconstructing cycles of land use and the role that fire played in shaping the landscape. Therefore we shall consider different aspects of landscape management activities here.

On-site data

Methodological problems affecting the interpretation of on-site data include data collection techniques, sample sizes and representativeness, questions of interpretation of species composition (e.g. lack of modern analogues for the weed flora) and the problem of the ‘patchiness’ of wetland settlement layers with many factors influencing the artefact and ecofact composition of the samples. Extensive and profound research in the last few years has contributed to a better understanding of some of the methodological problems, but cannot be discussed in detail in this context (see the above mentioned OSM-chapters).

On the basis of archaeobiological analyses of more than 100 sites located in different natural environments of the prealpine regions (Figures 3 and 4) we can claim that our knowledge of Neolithic *animal and plant husbandry is quite detailed:* The economically most important domestic animals in the LN were cattle, pigs and sheep as well as goats (Schibler, 2006; Schibler, 2016 [in press]). For their successful keeping, at least semi-open land was needed. Animals also provided manure which may have played an important role in the agricultural system. An increase in herd sizes, mainly of cattle, towards the end of the LN has been observed (Ebersbach, 2002; Schibler, 2006 and Figure OSM 2). LN plant economy in the area under investigation was based on cereals on the one hand, and pulses, oil, fibre and medicinal plants on the other. The importance of the cultivars changed in the course of the LN (Figure OSM 3; see e.g. Jacomet, 2006; Jacomet, 2007b; Herbig, 2009). For more details see OSM text, chapter 'Results of on-site data', and relevant literature cited there).

<INSERT FIGURE 3>

<INSERT FIGURE 4>

LN land use is mainly reconstructed with the help of weeds, largely on the basis of the weed spectra of cultivar stocks (see Figure 5 and OSM Table 5 and literature cited there). A compilation of all available data from the Northern Alpine foreland in the late 1990s revealed over 60 wild plant taxa that can be considered weeds in the LN (see tables in Brombacher and Jacomet, 1997, pp. 258–261; OSM Table 5). Beside annuals, perennials were also regularly present. There was a relatively diverse weed flora from the early phases of the LN onwards. Its composition is, however, not directly comparable to modern weed communities, which are dominated by annuals; we see the presence of many opportunistic 'weedy' taxa, which today are more typical of perennial ruderals stands, forest fringes etc., which had also spread onto the fields. The latter taxa were most probably mixed in with woodland, woodland edges, coppiced stands and so on.

<INSERT FIGURE 5>

The results of both classic archaeobotanical studies and FIBS analysis (Functional Attribute studies; see e.g. Bogaard 2004; for more details see OSM Text chapter 'Results of on-site data: Evaluation of the weed spectra') show coincidentally that the richest, most humiferous soils in the surroundings of the settlements were used for fields. The often high soil fertility values of the weeds point in the direction of some kind of manuring or to a naturally high soil fertility. Recently the analyses of ^{15}N isotopes in charred cereal grains from LN contexts have shown that some sort of manuring of the fields must have existed over longer periods (Bogaard, 2012; Bogaard et al., 2013; Styring et al., 2015 [in press]). The regular presence of annuals gives clear indications of highly disturbed soil conditions on the fields. This suggests a labour-intensive management of plots, which must have existed for at least several years, interrupted by only short fallow periods of no more than one to two years. Perennials capable of vegetative propagation by dividuals are also indicative of highly disturbed plots because they can regrow from small parts (see also Kreuz, 2012, chapter 7).

Intensive field tillage appears to have been in existence as early as the earliest phases of the LN, and it becomes even more pronounced from the middle of the fourth millennium cal. BC onwards, when annuals are recorded in increasing quantities. Without a high degree of disturbance, annual weed species would not have survived and would have rapidly become overgrown by competitive, mostly perennial weeds or woodland clearing taxa (see Figure 5).

There are also clear indications that stubble fields and fields left fallow were grazed, which had the side effect of manuring them (the same was noticed already in the early Neolithic LBK (LBK phase I to phase II; Kreuz, 2012). The regular presence of winter annuals points to winter cropping of at least some cereals (such as naked wheat or emmer), especially from Horgen times (around 3400 cal. BC) onwards. The results of the FIBS evaluation show that cereals were predominantly planted as winter crops (80% of the cases; e.g. Bogaard et al., 2013). Regular admixtures of small proportions of a second cereal in stocks suggest that some kind of crop rotation was practised, because it is an effective way of keeping pests and diseases at bay as well as to keep soil nutrient contents more balanced (Jacomet et al., 1989, p. 166 ff.).

In wetland settlement layers, animal dung, mostly of ruminants (sheep/goat and cattle) is very often encountered (a very good example is shown on Figure 6). Investigations of plant macro- and micro-remains (mainly pollen) in ruminant dung gave valuable indications of the surfaces on which the animals grazed (see e.g. Kühn et al., 2013; for more details see OSM text, chapter 'Results of on-site data', subchapter 'Evidence based on ruminant dung').

<INSERT FIGURE 6>

In several of the dung pieces of small ruminant investigated in different settlements covering the fifth and fourth millennia cal. BC there are clear indications that animals grazed on burnt surfaces of land, as evidenced by high amounts of micro-charcoal (Figure 7a and 7b; Kühn and Wick, 2010).

The seeds, vegetative plant parts and pollen in these pieces of dung point mostly to woodland as grazing ground, and not to the grazing of fields or ruderal/fallow places which were burnt before cereals were sown.

This suggests that LN people burnt parts of the woodland deliberately, probably to obtain more pastures (and also foraging and hunting grounds, see OSM text chapter' Results of on-site-data', subchapters 'Evidence based on open-land-taxa' and 'Evidence based on gathering and hunting') – as is well known from ethnographic sources from climatically similar regions (e.g. Smith, 2011). Remains of dung with plant spectra that would indicate the presence of stubble fields or fallow land do not contain high amounts of micro-charcoal (as shown by the lowermost sample on Figure 7b).

<INSERT FIGURE 7, A AND B>

Furthermore, evidence based on dendrotypology (dendroarchaeology) gives many indications of different types of woodland management, including coppicing and coppiced stands (see e.g. Billamboz, 2014; for more details see OSM chapter

'Results of on-site data', subchapter 'Evidence based on dendrotypology'). Gathering and hunting played an important role too and may have included targeted or specific landscape management practices, e.g. the tending of hedges or fruit trees. All these types of landscape management were intertwined and cannot be seen in isolation.

Off-site data

Like those affecting on-site data, the methodological problems of off-site data are manifold: they pertain to data collection techniques (e.g. is micro-charcoal counted or not?; or time resolution of the data), problems of species determination, the explanatory power of species correlated to lake/mire catchment areas, the question of actualistic comparisons, and the possible patchiness of prehistoric landscapes. Generally, as off-site data is extracted from natural environments, the differentiation between natural and anthropogenic impacts on the characteristics observed constitutes a major issue (Sugita, 2007a; Sugita, 2007b; Lechterbeck, 2013). Off-site information on human impact and landscape management is based on observations documenting, for example, rapid changes in woodland species proportions, increases in the percentage of open land in general, peaks of charcoal and an increasing importance of single species or their combination with species which prosper in disturbed or open environments, such as *Plantago lanceolata*.

To date, the quality and quantity of off-site data available is unevenly distributed over the prealpine area. The best investigated areas are the regions of Lake Constance and the Hegau (Rösch, et al., 2008; Rösch, et al., 2014; Lechterbeck et al., 2014), while data of the same quality (especially time resolution) from western or southern Switzerland is barely available.

During land-use phases of the fourth and early third millennia cal. BC, many high-resolution pollen diagrams of the western part of Lake Constance (Figure 8) show a strong decrease in *Fagus* in several phases (e.g. Rösch 2013; Rösch et al., 2014; Lechterbeck, 2013; Lechterbeck et al., 2014; ongoing research by. L. Wick; Figure 9).

In parallel, secondary forest elements such as *Corylus* and *Betula* and micro-charcoal increase. This is interpreted as a replacement of the *Fagus*-dominated woodland by semi-open or shrubby vegetation, probably also coppiced forests, coinciding with the beginning of the LN. The fluctuating micro-charcoal curves with high peaks are interpreted as indicating woodland burning, especially in the fifth and first half of the fourth millennium, when charred particles are much more frequent than those that are recorded both earlier and later. Therefore, the interpretation is that slash-and-burn cultivation was mainly practised in the earlier phases of the LN (most recently: Rösch, 2013; Rösch et al., 2014, see also OSM text chapter ‘Results of off-site data’). In the slash-and-burn model, fields are thought to have been rotated in a yearly cycle with long fallow-phases (over ten years) in between.

<INSERT FIGURE 8>

<INSERT FIGURE 9>

Recently the main line of interpretation that posits that high frequencies of micro-charcoal in off-site data are caused by anthropogenic burning connected to agriculture has triggered a revival of the slash-and-burn-hypothesis for Neolithic farming communities (see compilation in Schier [2009]), although it is a very old conception of how to begin farming in a wooded landscape (e.g. Clark, 1952; Modderman, 1971; older literature compiled by Troels-Smith, 1990; for a new synopsis see Isaakidou, 2011, p. 92 ff.).

To test the relevance of this interpretation, an experiment in a forested area of south-western Germany was designed (Rösch et al., 2002a; Ehrmann et al., 2014). The results show that slash-and-burn cultivation results in much higher yields than permanent cultivation (even with manuring). But these yields drop to near zero in the second year, forcing the constant relocation of fields. Clearing the forest, burning and preparing the fields leads to an average workload per hectare that is much higher than in permanent cultivation systems, and the demand for land is up to 16 times higher than for permanent cultivation. Rösch (2013, p. 114) points out that successful burning needs a very high amount of weak wood, i.e. a fallow phase of about 12 years is necessary to produce sufficient wood for another fire.

A further argument for-slash-and-burn cultivation is that there are (almost) no weeds in LN cereal stocks (Rösch et al., 2014, p. 131). This is in agreement with the experiments, where there were almost no weeds at all in the harvest.

The slash-and-burn hypothesis therefore combines a set of observations of LN on-site and off-site data: high charcoal peaks in pollen cores, a dense woodland to deal with at the beginning of the sequence, and finally high settlement mobility with sites occupied for just a few years up to slightly more than a decade (Ebersbach, 2010). The authors mentioned consider that it was the shifting cultivation pattern that could have forced people to move their settlements so frequently. This is seen as representing a contrast to the Early (LBK) and Middle Neolithic settlement patterns; at that time, according to the most commonly accepted hypothesis, settlements were permanent for periods of several hundred years (see e.g. Strien, 2005). As settlement duration and dynamics differ between the Early-Middle and the Late Neolithic, farming techniques must have differed too. Therefore, permanent agriculture in Bogaard's (2004) and Kreuz's (2012) view, is accepted for the LBK period, whereas similar results are rejected for the LN.

In a recent article, M. Rösch (2013, p. 115) admits that burning was perhaps independent from agriculture and carried out for other purposes such as hunting or animal husbandry. This is based on observations of an abundance of charcoal in LN coprolites of sheep and goat, but an absence of such charcoal in the Bronze Age (Rösch refers to unpublished data of L. Wick; see below). In an article of 2008 (Rösch et al., 2008, but also 2013, p. 115) Rösch considers that on-site data points to an intensification of agriculture in the later phases of the LN, in the Horgen culture (from around 3400 cal. BC onwards). However, off-site data still indicate that slash-and-burn agriculture and chopping down forests were being practised. He argues that it is not clear whether different agricultural regimes were being practised at the same time or whether the former slash-and-burn system was modified and improved, or both. One such modification could have been the fertilisation of permanent fields on the best soils and the preparation of such fields for cultivation by burning wood brought in from a coppiced forest on less fertile soils.

In Final Neolithic Bell Beaker times (around 2300 cal BC) – when settlements are located somewhat further away from the lakes – the slighter evidence of burning is seen in connection with the increased importance of animal herding and more extended pastures (Lechterbeck et al., 2014).

Discussion: Which land-use/landscape management is the more likely?

In the following section, the evidence and methodological aspects of the slash-and-burn hypothesis are discussed in detail and compared with other results from all kinds of data that could help us understand LN agricultural techniques and the wider economic and environmental context.

Is a comparison between Early/Middle Neolithic and Late Neolithic micro-charcoal values possible?

From the onset of the LN onwards (in the western part of Lake Constance around 4000 cal. BC) the micro-charcoal values in off-site pollen diagrams are up to five times higher than those of earlier phases (see Figure 9). But can we really compare Early and Middle Neolithic charcoal values with LN values?

In the off-site pollen diagrams from the western part of Lake Constance, micro-charcoal curves begin long before the LN; in fact micro-charcoal is present in the Mesolithic, although in lesser quantities than in the LN (e.g. in the diagrams of Durchenbergried and Hornstaad: Rösch, 1990; Rösch, 1992). This is also becoming apparent in ongoing work on Mainau (Figure 9), Schleinsee, Degersee and Buchensee (unpublished data by L. Wick). Micro-charcoal is also constantly present in the Early and Middle Neolithic periods, with even some high peaks during the Middle Neolithic in the Mainau diagram (Figure 9). Then, from around 3900 cal. BC onwards until 2500 cal. BC, very high charcoal peaks become visible. This is unsurprising, as the pollen diagrams mentioned are close to LN settlement areas, whereas they are rather more distant from the Early and Middle Neolithic settlement zones. Known Early and Middle Neolithic settlements were located at some distance from the lake rich morainic areas, around 20 km to the west, in the region of Hegau (LBK Flomborn phase settlement, from 5300 cal. BC onwards, at Hilzingen: Stika, 1991; Middle Neolithic Rössen culture settlement at Singen-Offwiesen: Dieckmann et al., 1998; Lechterbeck et al., 2014). It is, however, possible that the Middle Neolithic charcoal peak in the Mainau diagram (around 4600 cal. BC; Figure 9) mirrors settlements nearby whose archaeological traces have so far eluded us (like in the region of Zurich, Erny-Rodmann, 1995; Ebersbach et al., 2012). As cereal type pollen is also present, we can exclude that these traces were left by late hunter-gatherers.

In order to establish whether there was a real difference between micro-charcoal amounts in the Early/Middle Neolithic on the one hand and the LN on the other, we would need to have at our disposal off-site pollen-cores in the immediate proximity of Early/Middle Neolithic settlements. There is, however not a single (!) pollen diagram near an Early Neolithic LBK settlement in which micro-charcoal has been systematically investigated. Micro-charcoal was not counted in the Luttersee diagram (near an LBK-settlement in the region of Göttingen, Germany: Beug, 1992); neither was it counted in the floodplain profiles of the LBK-settlement region in the Wetterau (Hesse, Germany: Stobbe, 1996), or at Sersheim (near Stuttgart, Germany: Smettan, 1986).

To conclude, a direct comparison of LN off-site micro-charcoal from the lake-dwelling region with Early to Middle Neolithic micro-charcoal from the loess-regions is not possible because there are no equivalent data. If we cannot exclude a simple correlation between micro-charcoal peaks and the proximity of a contemporaneous settlement, then it will not be possible to reconstruct different land-use systems based on micro-charcoal values.

Are micro-charcoal values in off-site pollen diagrams related to cultivation?

Rösch (2013) argues for the existence of a slash-and-burn cultivation regime mainly in the earlier phases of the LN (the so called ‘Jungneolithikum’, see Figure OSM 1). But he concedes that in the later phases of the LN, from 3400 cal. BC onwards, a more permanent cultivation regime may have existed. However, in some profiles, the highest and most continuous micro-charcoal values occur after the ‘Jungneolithikum’, during the Horgen and Corded Ware phases (see Figure 9). This raises the question of why Horgen and Corded Ware people left so many traces in the micro-charcoal record if the landscape was already half-open bushland and cultivation had possibly become more permanent. And why does charcoal occur during all the periods analysed right up to the Late Bronze Age or even later? These questions remain unanswered. Furthermore, charcoal peaks which reflect the burning of woodland to create new fields should result in higher amounts of NAP after burning events, but a detailed analysis to establish whether such a correlation is really visible in the data has never been undertaken. In any case, it becomes obvious that the interpretation of micro-charcoal values is far from straightforward. The sources of charcoal could have been very diverse. A direct link between high micro-charcoal values and cereal growing and its cultivation techniques is merely one possibility among a number of possible interpretations. Another would involve the burning of stubble fields to reduce the weed flora and pests (e.g. Kreuz et al., 2014). Hearth fires or catastrophic fires which burnt the settlements down (the latter was quite frequent, as we know from on-site data) are a further possible source of charcoal. That the input from hearths is likely to be considerable can be demonstrated by a rough and conservative calculation: if fifty households burn just 5 kg of wood per day, then in the course of

20 years more than 1800 tons of wood would be turned into ash and charcoal. Since the settlements were located on the shore and were flooded at least seasonally, there should be traces of such quantities of material, at least in off-site sediments close to the shore.

Occasional conflagrations would have increased the amount of charcoal. Be that as it may, if all the micro-charcoal was derived from hearth fires, we should at least see the same quantities in the Bronze Age, which is however not the case. Finally, natural fires could theoretically also be considered, but there are no pre-Neolithic micro-charcoal peaks which point in this direction in the region under consideration.

To conclude, the interpretation of micro-charcoal values in off-site high-resolution pollen diagrams is extremely ambiguous, and clear conclusions about the type of cultivation regimes applied in the LN cannot be drawn. It is however true that the highest average values are reached during the LN. This was obviously a period when burning played a more important role, and it is highly likely that the source of at least a (large?) part of the charcoal comes from 'burning the landscape', whatever the reason was (see below).

Can experiments prove shifting cultivation during the LN?

Experiments are of great value for testing the plausibility of one or another hypothesis. However, experiments concerning land use are very difficult to set up; for instance the soil conditions are never the same today as they were thousands of years ago. Experiments are therefore not in themselves a proof – just because 'it works' – that prehistoric agricultural techniques were of one type or another.

The group around M. Rösch has tested experimentally the land-use system (slash-and-burn) it had reconstructed on the basis of the high charcoal values in off-site pollen diagrams (see previous sections for citations). They concluded that slash-and-burn agriculture is the best, if not the only, method to practise successful agriculture with Neolithic tools and methods in a forested area on non-optimal soils. However, their experimental design has several drawbacks. First of all, the experimental plots are situated on soils with a pH-value that is comparatively lower than the usual values of the morainic soils in the hinterland of the lakeshore settlements. This reduces the availability of nitrogen and phosphorous. Rösch et al. (2002b, p. 30 ff.) state that the ash from burning, which raises the pH value, counteracts this. In addition, the plots were not thoroughly weeded – in opposition to what the weed composition indicates for Neolithic fields (see above). The results from unburnt plots showed that yields were very low or even non-existent, while they were high on burnt plots, where the fire had reduced competition by weeds, raised the pH value, and removed fine roots from trees and former forest vegetation (for yields, see next section). It is hardly surprising that unburnt plots give little yields when they are located on acidic soil and left unattended, but this is not comparable to the techniques used in permanent cultivation systems. The result is therefore an unavoidable consequence of the experimental design and cannot be transferred to prehistoric settings.

Finally, the experimental plots were relatively small and surrounded by dense woodland, a setting which is again not comparable to Neolithic environments, at least not after a few hundred years of human impact, in the periods after 3500 cal. BC.

Despite their flaws, these experiments are of great value, because they have shown that shifting cultivation may have been feasible during Neolithic times in temperate woodlands north of the Alps. The experiments have also produced interesting data on workload in relation to yields and on the amount of woodland necessary to maintain a shifting cultivation system for several hundred years. The ratio of field under cultivation to fallow land turned out to be about 1:36 and therefore only 3% of the area around the settlements could be used for crop growing – the other 97% being used to produce fertilizer in the form of charcoal (Rösch, 2013). Above all, the higher workload and the much higher demand for land when applying a shifting cultivation system may have caused a problem (as the experiments have also shown). Before burning, the trees had to be cut down, the wood dried and transported to be stored in heaps. All this is hard and time-consuming work and would not have been undertaken without good reason (the very high yields, see above).

There are other types of experiments which have shown that permanent cultivation may have worked in Neolithic times. Unfortunately they are located on soils over loess in the Rhineland, and are therefore rather distant from the lake-dwelling area. Such an experiment was carried out by Cologne University in the Hambach forest (Lüning and Meurers-Balke, 1980). The results obtained there were later used by Bogaard (2002) for her interpretation of Early Neolithic land use.

To conclude, modern experiments inevitably have their shortcomings; in the best case they can provide insights into how cultivation *may* have worked. They are, however, not a proof of the existence of one or another cultivation regime in prehistoric times, and their results should not be used as a main line of argument for reconstructing former farming regimes.

What were the yields when applying different forms of cultivation regimes?

Estimates of how high the yields in LN times may have been differ greatly, and we are far from having answered this question (for an overview see Bogaard, 2004, table 2.1). Historical data from medieval Europe with very low yield values (450–900 kg/ha) are based on three-field systems which had suffered from permanent cultivation that lasted for centuries and had too little manure input (see Reynolds, 1997). Most authors therefore agree that these data are hardly comparable with Neolithic data. Kreuz (2012, pp. 123–124) assumes a minimal yield of 800 kg/ha for cereals and legumes for the early Neolithic LBK if the ratio between sown and harvested crops is 1:10; this corresponds to modern yields considered as 'good' in the traditional agriculture of the central Anatolian highlands where the climate is harsh (Ertug-Yaras, 1997, p. 229). Ethnographic data from a mountainous area in Asturias (northern Spain) show higher yields: there, manured and intensively worked permanent plots produce rather high yields of over 1500 kg/ha over many years (up to 1800–1900 kg/ha were recorded; Bogaard, 2004, table 2.1; see also Charles et al., 2002). Intensive garden cultivation including irrigation and manuring with up to 40 t/ha can increase yields to up to 2500 kg/ha, and for barley even up to 3000 kg/ha (Ebersbach, 2002, 133 and villages 18A–C).

The yields on the experimentally burnt plots at Schwäbisch Hall-Wackershofen and Forchtenberg in south-western Germany mentioned above were very high in the first year (2500–4000 kg/ha; only old strains of cereals considered; Ehrmann et al., 2014, p. 16), being close to the yields obtained by modern agriculture. In the following year, however, they dropped to near zero; the authors conclude that permanent cultivation with tillage but without fertilizer is not possible in south-western Germany. This is in strong contrast to manured and intensively cultivated permanent plots like those in Asturias which continue to give quite high yields for many years. There are also several 'long-term-cereal growing' experiments like the Rothamstead experiment (see Bogaard, 2004, p. 23 f.) that gave reasonable yields over many years, even without manuring (see for more information see Baum et al., submitted).

To conclude: assumptions about the amount of agricultural land needed in Neolithic times can vary dramatically depending on which yield values and which agrarian techniques we use. Quite intensive cultivation methods ('garden-like' to use Bogaard's words, 'park-like' in the early Neolithic LBK according to Kreuz) coincide with small plots of less than half a hectare per person to meet the calorie requirements, while slash-and-burn techniques with a twenty-year-rotation system may need up to ten times more land in the vicinity of the villages and have to be kept undisturbed to allow for forest regrowth to fuel the next burning event. Yields mainly depend on the nutrients available for growing, and these can be kept to a sufficient level by different methods: regular shifting of fields to 'virgin' soils, burning, manuring, or good crop rotation systems including pulses.

What can on-site data contribute to explain the high micro-charcoal values in off-site locations?

Because off-site micro-charcoal values are clearly difficult to interpret and experiments have drawbacks we must consider other evidence for reconstructing plausible landscape management systems in LN times. On-site data confirm the off-site observations that burning parts of the (wood-) land was an important element of Neolithic land management systems. Micro-charcoal in faeces of sheep and goat in combination with other plant remains point mostly to woodland as grazing grounds (Figure 7). Domestic animals grazed areas of woodland that had previously been burnt, but without any indications that fields existed in the same areas at the same time. Burning may therefore have been a method of creating pastures. We thus have good evidence from on-site data that the main source of high micro-charcoal values in off-site pollen diagrams can be attributed to attempts by LN people to open up the landscape for better grazing, possibly also to create hunting and gathering grounds. Such techniques are known from ethnographic sources, e.g. among North American Forest Indians (e.g. Smith, 2011).

A secondary vegetation rich in shrubs developed on such burnt surfaces – as well as in managed woodland – as clearly shown by the off-site pollen data, but also illustrated by the large amounts of gathered plants and the growing diversity of hunted open-land animals in the LN (see OSM text chapter ‘Results of on-site data, subchapter ‘Evidence based on gathering and hunting’). As Lechterbeck (2013, p. 134, based on the literature cited there) has noted, burning supports the growth and flowering of hazel. Hazel is relatively fire resistant because of its robust rootstock from which shoots rapidly re-grow. Already present in the undergrowth of the forest, hazel could spread and flower more easily when larger trees were cleared away. However, an unhindered spread of bushes, but also of coppices, is only possible when grazing animals are kept away. As Bleicher and Herbig (2010) have shown, and as corroborated by many historical sources and modern observations, goats successfully prevent the regrowth of forests. It is mainly goats that are important for clearing land overgrown, for instance, by brambles (*Rubus fruticosus*), and goats may have primarily been kept for such a purpose. The high frequency of *Rubus* prickles found in sheep/goat dung supports this idea (see e.g. Kühn and Wick, 2010). In any case no secondary forest would grow on patches of previously burnt land if a certain number of goats, sheep and cows were grazing there. If a slash-and-burn system was practised, the rapid and undisturbed regrowth of the forest would have been necessary and hence grazing by small ruminants on burnt woodland patches should have been avoided. What then were the causes of the development of secondary woodland?

We have very good indications from on-site data that at least parts of the domestic herds were kept away from the settlements, even at a large distance (see e.g. Kühn and Hadorn, 2004), and were probably accompanied by herdsmen and dogs to prevent the animals from grazing where inappropriate. In the LN Federsee basin the settlement of Alleshausen-Grundwiesen was probably a seasonally used camp for cattle and herdsmen (Bleicher, 2009, p. 128 ff.), combined with the (summer) cultivation of flax. Here the cultural layers consist almost entirely of cattle dung.

Is the high degree of settlement mobility caused by the slash-and-burn economy?

One of the most intriguing traits of LN wetland settlements is their instability, short lifetime and repeated relocation. Recent studies have shown durations of occupation of less than twenty years, in some cases even less than ten years for entire settlements with several dozen houses (Ebersbach, 2010; Ebersbach 2013, 294; Schlichtherle et al., 2011). It is of course tempting to see a causal connection between the huge land requirements of slash-and-burn cultivation and the high degree of settlement mobility. Instability and mobility also occur at a level beyond settlements and within settlements. In the Federsee area several contemporaneous sites were relocated within five- or ten-year cycles at the same rhythm, as Bleicher (2009) has shown.

Within settlements the life cycles of single houses can be much shorter than the duration of occupation of the settlement as a whole, with ‘pioneer houses’ often erected two or three years earlier than the majority of the houses, and groups of houses already abandoned after a few years (see e.g. Leuzinger, 2000; Doppler 2013). We therefore conclude that groups of people inhabiting one or several houses, but not comprising the inhabitants of a whole settlement, moved in and out of the settlement at different times; a settlement was not a stable unit in itself.

If and how such behaviour is connected to agricultural activity or to other factors such as social tensions, alliances and personal networks, is unknown and open to debate. Some authors have suggested that the rapid depletion of forests –as shown by dendrotypology – caused the relocations, as suitable timber is one of the resources needed in huge quantities when establishing a settlement (see Billamboz, 2010; Billamboz, 2014). In addition, rises in lake levels or demographic growth may have been the reason for the instability and short life of LN settlements (Pétrequin, 2013). Although it is usually difficult or impossible to prove that a connection existed between two settlements directly following each other in time, the striking example of Hornstaad Hörnle 1A suggests that reasons other than following the movement of slash-and-burn fields were at the root of high settlement mobility: the settlement was founded in 3917 cal. BC and grew to around 50 houses before it burnt down in 3910 cal. BC. Immediately afterwards, in

3909 cal. BC, parts of the settlement were rebuilt, and a new settlement – Hornstaad Hörnle 3 – was established only a few hundred metres away (Billamboz, 2006).

It can be assumed that between two settlement phases a succession took place on former cultivated plots, but also on land used for other purposes (Bleicher and Herbig, 2010). It is more or less necessary for settlers to remove regrown vegetation including bushes in order to reclaim former plots for the next settlement phase of fifteen or so years, and fire would be the easiest way to do it. The 'pioneers' may have had the task of preparing the fields for the arrival of the rest of the settlers. Bleicher and Herbig (2010) also argue that the highly interconnected and mobile settlement structure led to almost identical open-land plant spectra in the various settlements, and that domestic animals may have played an important role in building up these meta-populations in the open surfaces. This can be corroborated by spectra from other parts of the lake-dwelling area, for example the region of Zurich. Furthermore, dendrotypology has documented the existence of intensive and lasting woodland management, with different patches of secondary forest kept free of grazing animals and other disturbances to provide the timber favoured for house posts after approximately twenty years. On sites like Saint-Blaise (on Lake Neuchâtel) the repeated use of possibly the same forest patches for successive settlement phases at the same site was visible in the growth history of timber (Gassmann, 2007).

In sum, continuous and strategic land and forest management within the same regions may have contributed to the gradual opening of the landscape; this can be seen in all archaeobiological data gathered for the LN, especially after 3000 cal. BC.

At the same time there are also indications of additional seasonal movements of people and animals into alpine areas, as evidenced for example in dung pieces containing plants growing at higher altitudes in the Alps (Kühn and Hadorn, 2004). Such movements to higher altitudes – a kind of transhumance – are also indicated by Sr^{87}/Sr^{86} isotope analysis of cattle bones (Doppler et al., 2015 [in press]). The use of mountainous areas by herdsmen is also corroborated by off-site pollen data, e.g. from the Vogelsberg, the Eifel region and the Black Forest (see discussion in Kreuz et al., 2014, p. 91 ff. and literature cited there) in which LN activities linked to opening up the forest, including the use of fire, are traceable.

In conclusion, cycles were an integral part of the LN economy. Different kinds of on-site data indicate that burning woodland during the LN played an important role. However we do not see a direct correlation between agricultural activities and burning in our empirical datasets nor do we have proof that high settlement mobility was caused by-slash-and burn agriculture. What is clearly visible, on the other hand, is that the landscape was being burnt to create pastures, hunting and gathering grounds. Connections between settlement dynamics, land-use management systems and the individual mobility of people and animals may have been much more complex and caused by many different factors. We are convinced that they can only be traced if all the available data, including settlement archaeology and questions pertaining to the social structures of prehistoric societies, are combined and tackled in a transdisciplinary approach.

The question of the number of weeds in cereal stocks: what is 'a few'?

One of the main arguments used by proponents of a shifting cultivation model is that 'even assuming ear harvest, the small proportion of weeds [...] is striking and resembles the purity of the harvest from the Forchtenberg slash-and-burn fields' (Rösch et al., 2014, p. 129). First of all, the number of weeds per stock at Hornstaad varies greatly – there are from 12 to 140 remains of annuals and from 2 to 49 remains of perennials (see OSM Table 5). The number of taxa is between 4 and 15 annuals and 1 to 8 perennials (see OSM Table 5).

Numbers might indeed be low, but usually there are at least some. The number of weed seeds found in stocks depends on the cleaning stage, but also on the volume of the samples analysed. If we analyse small samples of a maximum of 500 ml – which was in fact almost always the norm (the Hornstaad samples were also very small) – conclusions about the number of weeds present on Neolithic fields are purely hypothetical. A much more thorough analysis of uncleaned stored crops remains to be undertaken.

LN stocks represent very short-term, single events at a given stage of cleaning. This may contrast with, for example, Early Neolithic cleaning residues in pits (Bogaard, 2011b; Kreuz, 2012), which could represent longer term accumulations of numerous single (but similar) events (Kreuz, 1990). Over time, a larger number of weeds (together with chaff) may have accumulated. The generally higher average quantity of weeds in LBK pits could reflect this.

The number of taxa in LBK pits, however, is fairly similar to that found in the most diverse Hornstaad stocks (see OSM 5). Therefore, Rösch et al.'s statement (2014, p. 130) that weed percentages at Hornstaad are lower compared to Vaihingen is not comprehensible. It would be more fruitful to compare the weed spectra from LBK pits to the weed spectra from mixed samples in lakeshore settlements, which may represent several years of accumulation. Such evaluations remain to be undertaken but are difficult to carry out because of the mixed character of the assemblages.

Differences in the weed and cereal spectra of the successive Neolithic periods

We do not see major differences (or almost no differences at all) between the weed spectra of the Early Neolithic and those of the LN (see OSM Table 5). In both periods, annual weeds dominate in the stocks (but also in mixed samples; see Figure 5) and many of the weed taxa are the same (see OSM Table 5). The few visible differences may be explained by the 1000 years or more that elapsed between the two periods, a time when new taxa from outside Central Europe may have reached our region, and by differences in the surrounding landscape and vegetation. We cannot, on the basis of the weed evidence, agree with Rösch et al.'s argument (2014, p. 130) that land use systems of the later stages of the Final and Late Neolithic were totally different from the land use of the Early Neolithic. Thus we also do not understand why Rösch (see cited works) and also Schier (2009) accept intensive land use in the Early Neolithic and reject it for (mainly the earlier stages of) the LN. In our view it is not surprising that the few FIBS evaluations of LN weed spectra by Bogaard (2004; 2011a) gave the same results as those of the Early Neolithic: they point to permanent fields, which were intensively worked and maybe even manured (Bogaard et al., 2013; Styring et al., 2015 [in press]).

Furthermore, there appears to be no great differences in terms of taxa composition when different periods of the LN are compared. In stocks of the earlier phases annual weeds are even more widespread than in stocks of the Horgen culture (late fourth millennium cal. BC). In the mixed assemblages, however, the number of annual weeds increases in the second half of the LN, which could indicate that winter cereal growing became more important and that the plots were more intensively maintained; perhaps pigs played some part here in working (and manuring) the fields as their numbers rise markedly with the onset of the Horgen culture (Figure OSM 2). Overall, we do not see substantial differences: permanent cultivation continued. This is also corroborated by the N isotope analyses of the 1200-year-long stratigraphic sequence recorded at Sipplingen on Lake Constance (Styring et al., 2015 [in press]).

The difference of the cereal spectra 'of the Late Neolithic from the phases before and after' (Rösch et al., 2014, p. 130) constitutes a further argument in favour of the shifting cultivation hypothesis. Here the authors refer to the dominance of tetraploid naked wheat in the first half of the fourth millennium cal. BC; but this type of naked wheat also appears in the second half of the fourth millennium in larger amounts (Figure OSM 3), and is still present in later periods (although never again in such large amounts). Moreover, the argument that there are more cereals in the earlier phases of the LN is not convincing given that a systematic comparison of density values, for example, has not been carried out. On the basis of the evidence from mixed assemblages (containing large amounts of chaff remains) we do not see such a difference.

More fundamental and greater differences in the weed and cultivar spectra appear with the onset of the Bronze Age (BA). South of the Alps this is apparent as early as the earliest phases of the BA, as the new on-site investigations of Early BA sites on the fringes of Lake Garda show (Perego, 2015). North of the Alps such developments become apparent with the beginning of the Middle to Late BA. We are therefore in complete agreement with Rösch et al.'s (2014) statement that the 'extensive ard land-use systems of the Bronze Age were different in terms of agricultural practices' (see also Jacomet and Brombacher, 2009). Not surprisingly, a FIBS analysis of charred chaff and weed remains of Middle BA pits in central Switzerland showed that cereal growing was carried out at that time on larger, extensively worked fields (Zibulski, 2001; Bogaard, 2011a).

Differences between modern experimental fields and Neolithic weed spectra – how long does it take for Neolithic-type weed floras to develop?

The fact that the composition of the weed flora is different from today's fields cannot be taken as an argument to prove the existence of shifting cultivation (see above and OSM text chapter 'Results of on-site-data indicative of the farming regime and landscape management'). A comparison of the wild plant lists of experimental fields treated with slash-and-burn in Wackershofen and Forchtenberg (Rösch et al., 2002a) with Neolithic weed spectra (Figure 5 and OSM

Table 5) clearly shows that they are completely different. It is therefore not possible to propose an interpretation of Neolithic weeds on the basis of the experimental wild plant spectrum. The closest similarity is provided by the spectra of the experimental 3-field-system at Wackershofen. This is in agreement with our expectations but suggests rather the opposite of shifting cultivation.

The results of experiments assessed in the course of the Hambach experiment (near Cologne, Germany) mentioned earlier showed that Neolithic-type weed floras need ten years or more to develop (Bogaard, 2002; Bogaard, 2004; Bogaard and Jones, 2007). Although these experiments had several drawbacks, at least they showed that there were weeds on the fields. With shifting cultivation there should have been no weeds at all (let us recall the statement cited above referring to the 'purity of the harvest from the Forchtenberg slash-and-burn fields' by Rösch et al., 2014), either in the stocks nor in the mixed samples from the cultural layers. As this is not the case, we reject the hypothesis of a LN shifting cultivation based on empirical on-site data.

Soil fertility issues in the LN

All on-site data point to fertile soils. The nature of the soils in the loess belt of Central Europe is a matter of debate (see e.g. Eckmeier et al., 2007). What is certain is that in very dry regions like parts of the Wetterau there were highly fertile czernozems that had developed naturally on a small scale (pers. comm. Prof. H. Thiemeyer, Frankfurt). It is not certain whether luvisols later developed out of these, or whether they had developed directly on loess in less dry regions. The latter is supposed by some researchers (Brönnimann and Rentzel [in prep.]). To summarize, soils in the loess landscapes were fertile and well suited to agriculture, but czernozem development is likely to have been regionally limited. Regarding soil fertility, therefore, the prealpine luvisoils that developed on the subsoil of the last glaciation were probably not all that different from luvisoils on loess. It has yet to be determined how different prealpine Neolithic luvisols on morainic ground were from luvisols in Early Neolithic loess landscapes. We therefore do not agree with Schier's (2009) view that a spread of Neolithic agriculture beyond the fertile loess areas was only made possible through slash-and-burn cultivation.

Really poor soils, mostly on siliceous bedrock, exist in several mountainous areas of Central Europe. In regions like the southern part of Westphalia (Rothaargebirge) (Pott, 1986), or the central Black Forest, or the Emmental in Switzerland, we know of cultivation regimes known as 'Haubergswirtschaft'. Such regimes included the cyclical use of patches of land cleared by burning. It was not possible to produce a cereal crop on these parcels of land (mostly rye was sown, a cereal that grows extremely well on poor soils but which was not introduced to our region before the Late Roman period); they were intended to provide firewood, charcoal, bark for tanning etc. and the burnt surface was used as pasture. Similar regimes are known in Scandinavia, e.g. in Finland (Lahtinen and Rowley-Conwy, 2013). In such regions, slash-and-burn may have been the only option to produce a crop. Whether slash-and-burn was also practised in the surroundings of some Neolithic sites of unknown character in the south-western French Alps remains to be clarified; there, einkorn, a cereal of which certain strains grow well on poor soils today (Bogaard et al., 2016), plays a quite important role (Martin, 2014).

Some new isotope data (Bogaard et al., 2013) even suggest that manuring was practised from the Early Neolithic onwards. Similar results were obtained by Kanstrup et al. (2014) for the fourth millennium cal. BC onwards in Denmark. In Hornstaad there are indications that the manuring of fields in which different cereals were grown was not the same, and there is also variation in the data obtained in different parts of the settlement (Bogaard et al., 2013; Styring et al., 2015 [in press]), suggesting that manuring rates varied spatially and according to the species grown in a given year. All in all it seems that the interdependence between animal herding and plant cultivation was strong (Ebersbach, 2002). To be efficient, manuring needs a certain minimal number of domestic animals on the one hand, and on the other hand manuring has important implications for the investment in land and territorial claims by farming groups (see Bogaard, 2012). A

Tamil proverb puts this succinctly: ‘No fodder, no cattle, no manure, no crop’ (cited by Thomas, 2000, p. 4). The question of soil fertility and how to keep it high (by shifting fields or manuring, not forgetting crop rotation systems) is surely one of the most important research issues related to land-use management.

To conclude, empirical weed data point to permanent cultivation from the beginning of the LN onwards with no profound differences from what we know for earlier phases of the Neolithic. There are no convincing arguments, based on empirical data, that support the existence of shifting cultivation. Soil fertility was no doubt a crucial issue, but it can be kept at a high level by using different techniques, and recent isotope data indicate that manuring played an important part already in the Neolithic.

Conclusions

Although the on-site results presented in this article are very encouraging, archaeobiologists are still far from being in a position to reconstruct the LN economy and environment comprehensively. First of all, future research needs to reach a better understanding of wetland layer formation processes (ongoing SNF Project IPAS Basel, no. CR30I2_149679). Based on this, much more research on the functional attributes of weed taxa is needed. Analyses of ^{15}N isotopes in cereal grains (and perhaps other cultivars) will be crucial to understand manuring techniques – which in turn are connected to animal keeping strategies. Much more dung analysis is also needed, and more systematic comparisons between on-site micro- and macro-remain data. Nevertheless the existing data already allows us to draw a quite plausible picture of how the LN economy may have worked and what impact it had on the landscape.

On-site weed data point to permanent, rather intensively tilled fields and maybe even the use of manure. However we cannot exclude that on a freshly cleared piece of land cultivation was practised for a short time – if fire was used. Some kind of in-field out-field system may well have existed, with most fields cultivated permanently and intensively in the vicinity of the villages and some out-fields occasionally prepared on burnt forest land. Moreover, there was a very close and intense relationship between plant and animal husbandry.

Settlement archaeology and dendroarchaeology both show that relocations and cyclical patterns were an integral part of the LN economy. Settlements were short-lived and people moved around within settlement areas (or even between them) with their domestic animals. For clearing land they undoubtedly used fire as a landscape management tool, as shown by micro-charcoal in dung and off-site data.

On-site data also confirms that gathering (see e.g. Antolin et al, 2015 [in press]) and hunting were highly important. Part of the gathering system consisted probably also of woodland management, including coppicing and perhaps pollarding. Such an intensive use of wild resources lets us suppose that people manipulated the landscape to obtain higher and more secure yields of wild fruits and good timber for building purposes. An opening of the landscape also favours successful hunting. And the necessity to provide good grazing grounds for domestic animals (especially cattle) was crucial. As our on-site data also show, this landscape management included the use of fire, creating in the process mosaics of micro-environments such as liminal areas, bush-rich landscapes, etc. This fits well with niche-construction theories (e.g. Smith, 2011). All in all, LN people had a successful survival strategy (see also Baum et al., submitted). It was clearly resilient, able to cope with changing weather conditions or short-term climatic fluctuations.

Using on-site data – in combination with an alternative interpretation of off-site data – the surface areas needed to feed humans and animals can be estimated in a more realistic way. On-site data are therefore an important basis for model-based simulations on a small scale (e.g. Baum, 2014; Baum et al., submitted, and ongoing research by Baum). These modelling attempts have shown that the amount of open or semi-open land is fundamentally different depending on which farming regime it relies on (Figure 10; Baum, 2014). On the basis of a combination of on- and off-site data we consider the model shown in Figure 10a as the most reliable.

Modelling approaches have the potential to open-up wider archaeological perspectives on the practices and impacts of early agrarian societies (Whitehouse and Kirleis, 2014). Moreover, the results can be incorporated into land cover simulations on a larger scale, e.g. of the Early Anthopocene (Kaplan et al., 2009; Kaplan et al., 2011; Ruddiman, 2004; Ruddiman, 2013; Ruddiman et al., 2011; Ellis et al., 2013). For all this, it is crucial to bring together – in an integrative way – as many types of palaeoenvironmental proxies as possible in order to gain more plausible insights into the landscapes that existed thousands of years ago. We believe that this article contributes to this goal.

As a final offering, we propose to re-write the conclusions of Lechterbeck et al. (2014, p. 108): 'Some very elaborate land use models based on experimental data suggest that the expansion of secondary forest elements was caused by "slash and burn" or "swidden" cultivation (Rösch, 2013; Schier et al., 2013)'. A more appropriate formulation, based on a comprehensive knowledge of on-site data, would be: 'The expansion of secondary forest elements was caused by different landscape management practices which included the use of fire'.

Acknowledgments

This study was conducted partly within several projects of the SNF (Swiss National Foundation), mainly project no. K-13K0-117897 (The role of Animal Fodder in

Neolithic and Bronze Age Subsistence Economy and its Palaeoecological Implications), and the currently running project no. CR30I2_149679 (Formation and Taphonomy of Archaeological Wetland Deposits: Two Transdisciplinary Case Studies and their Impact on Lakeshore Archaeology). Information was also provided by the ongoing SNF project CR12I2_143815/1 on Sr^{87}/Sr^{86} isotope analyses (PI: J. Schibler). We also thank the canton und town of Zürich who have funded former investigations and especially the ongoing research on the recently excavated site of Zürich Parkhaus Opéra. The first author thanks Angela Kreuz (Landesamt für Denkmalpflege Wiesbaden, Germany) for her valuable comments on an earlier version of this article. We also thank Urs Leuzinger (Amt für Archäologie des Kantons Thurgau) for information on finds of ards and ardmarks, and Manfred Rösch who kindly provided unpublished data (Mainau diagram). Finally, we thank two anonymous reviewers whose comments enabled us to make the text much more concise, and Madeleine Hummler for help with our English wording.

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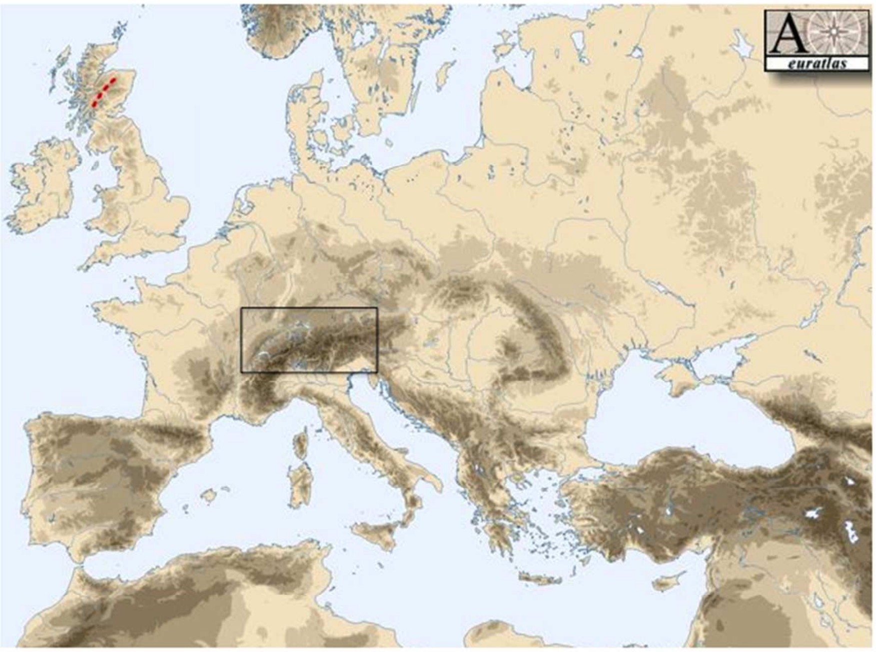
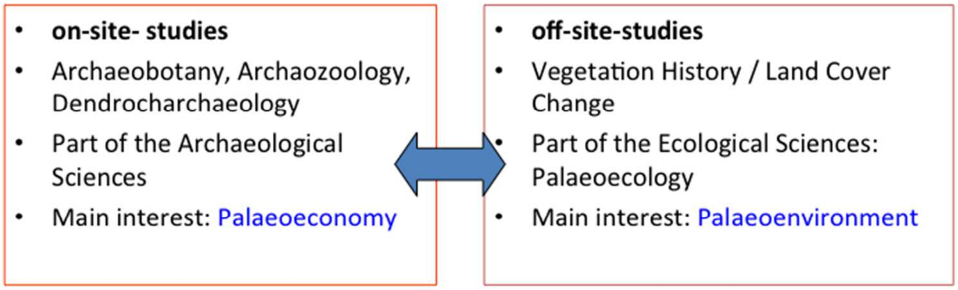


Figure 1. Map of the area considered in this article. From Euratlas http://www.euratlas.com, slightly modified by S. Jacomet.
254x190mm (72 x 72 DPI)

Fig. 2, Jacomet et al.



- **on-site- studies**
- Archaeobotany, Archaozoology, Dendrocharchaeology
- Part of the Archaeological Sciences
- Main interest: Palaeoeconomy

- **off-site-studies**
- Vegetation History / Land Cover Change
- Part of the Ecological Sciences: Palaeoecology
- Main interest: Palaeoenvironment

Figure 2. Scheme showing the relationships between the different types of palaeoenvironmental data considered in the text (on- and off-site data). By S. Jacomet.
254x190mm (72 x 72 DPI)

Fig. 6, Jacomet et al.

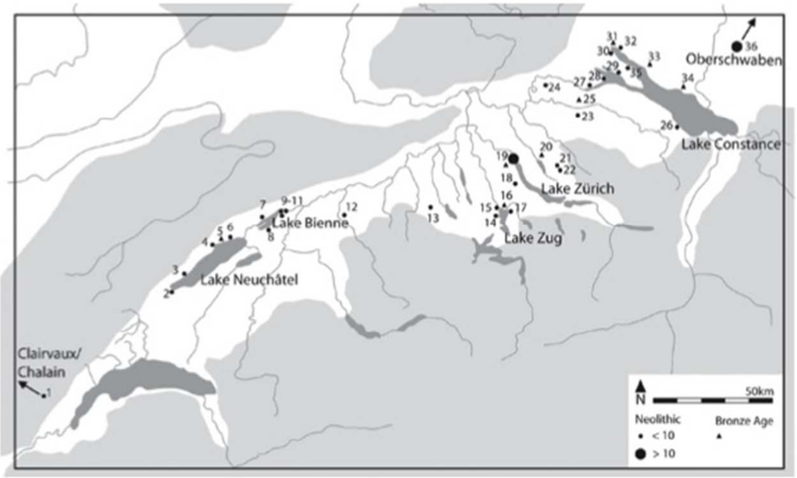


Figure 3. Map of Neolithic and Bronze Age sites of the northern alpine lake dwelling area for which archaeobotanical data exist. Neolithic sites date between 4300 and 2400 cal BC, Bronze Age sites between 1900 and 850 cal BC. On most of the sites several settlement layers of different ages were investigated. For detailed legend and references see Tables OSM 1 and OSM 2.
254x190mm (72 x 72 DPI)

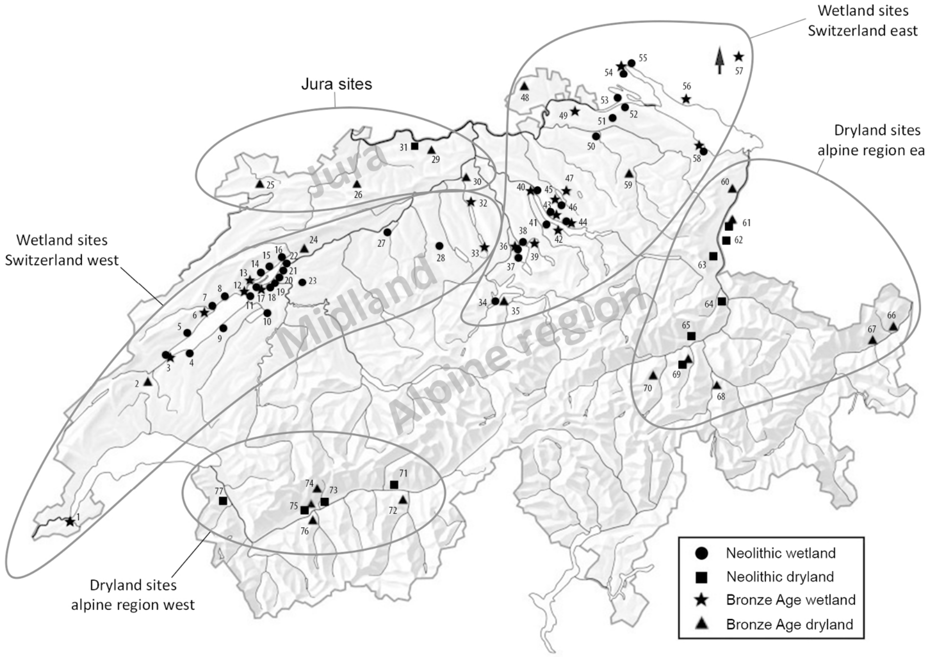


Figure 4. Major regions of Switzerland and location of Neolithic and Bronze Age wetland and dryland sites with archaeozoological data. For detailed legend and citations see Tables OSM 3 and 4 (from Schibler, 2016, [in press]).
169x121mm (300 x 300 DPI)

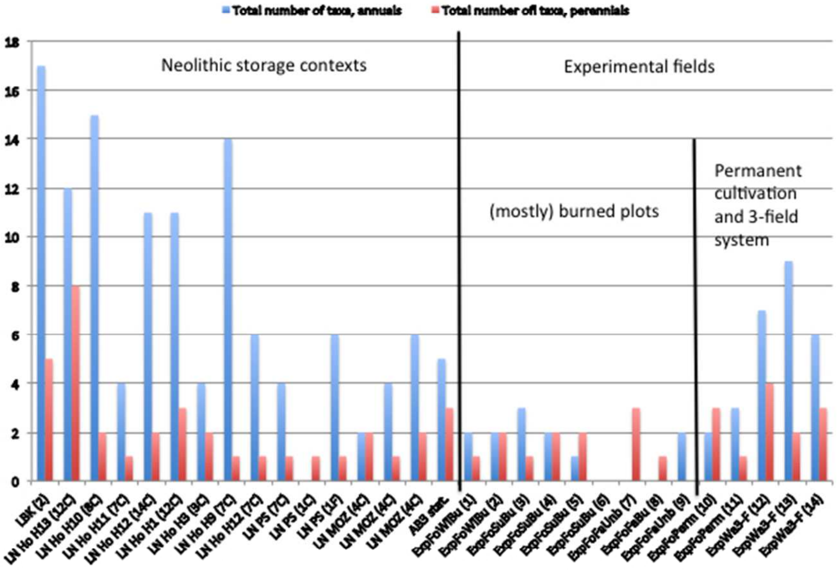


Figure 5. Numbers of annual (blue) and perennial (red) weeds in Early and Late Neolithic cereal and flax stores (from Maier, 2001; Brombacher and Jacomet 1997; Brombacher and Jacomet 2003; Kreuz 2012) compared to those of the experimental fields at Wackershofen and Forchtenberg (data from the latter after Rösch et al., 2002a). Abbreviations: LBK = LinearBandKeramik (Early Neolithic); LN = Late Neolithic; Ho = Hornstaad Hörnle I, AH (Archaeological Horizon) 2 (burnt layer); numbers in brackets mean number of stocks analysed; C = Cereals; F = Flax; MOZ = Zürich-Mozartstrasse; PS = Port-Stüdeli; AB3 = Arbon Bleiche 3; stat. = results of statictical analyses (Spearman Rank Correlation); in total 80 LN stocks considered. LNE = Earlier Phases of Late Neolithic (ca 4300-3600 cal BC; LNL = Later phases of Late Neolithic (3300 – 2500 cal BC); ExpFo = = Experimental Fields in Forchtenberg; WiBu (1) winter sawn cereals, burned surface; SuBu = summer sawn cereals, burned surface; FaUnb = Fallow land, unburned; FaBu = Fallow land, burned; Perm = permanent cultivation; ExpWa3-F = Experimental Fields in Wackershofen, 3-field System; number in brackets = number of the relevee in Rösch et al., 2002a. For more details see Tables OSM 1 and OSM 5
254x190mm (72 x 72 DPI)

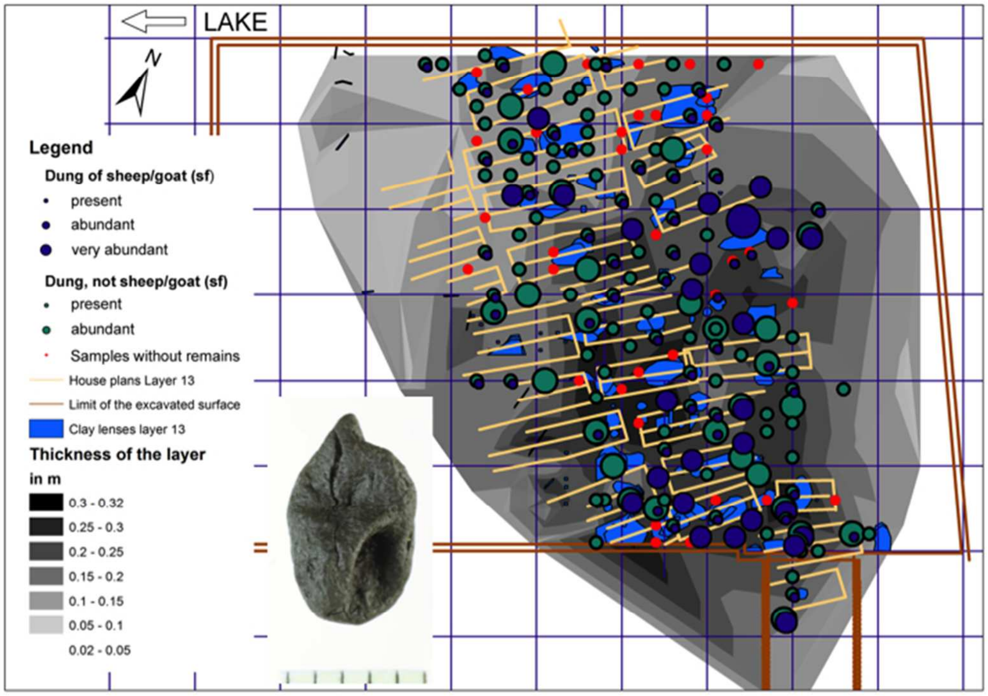
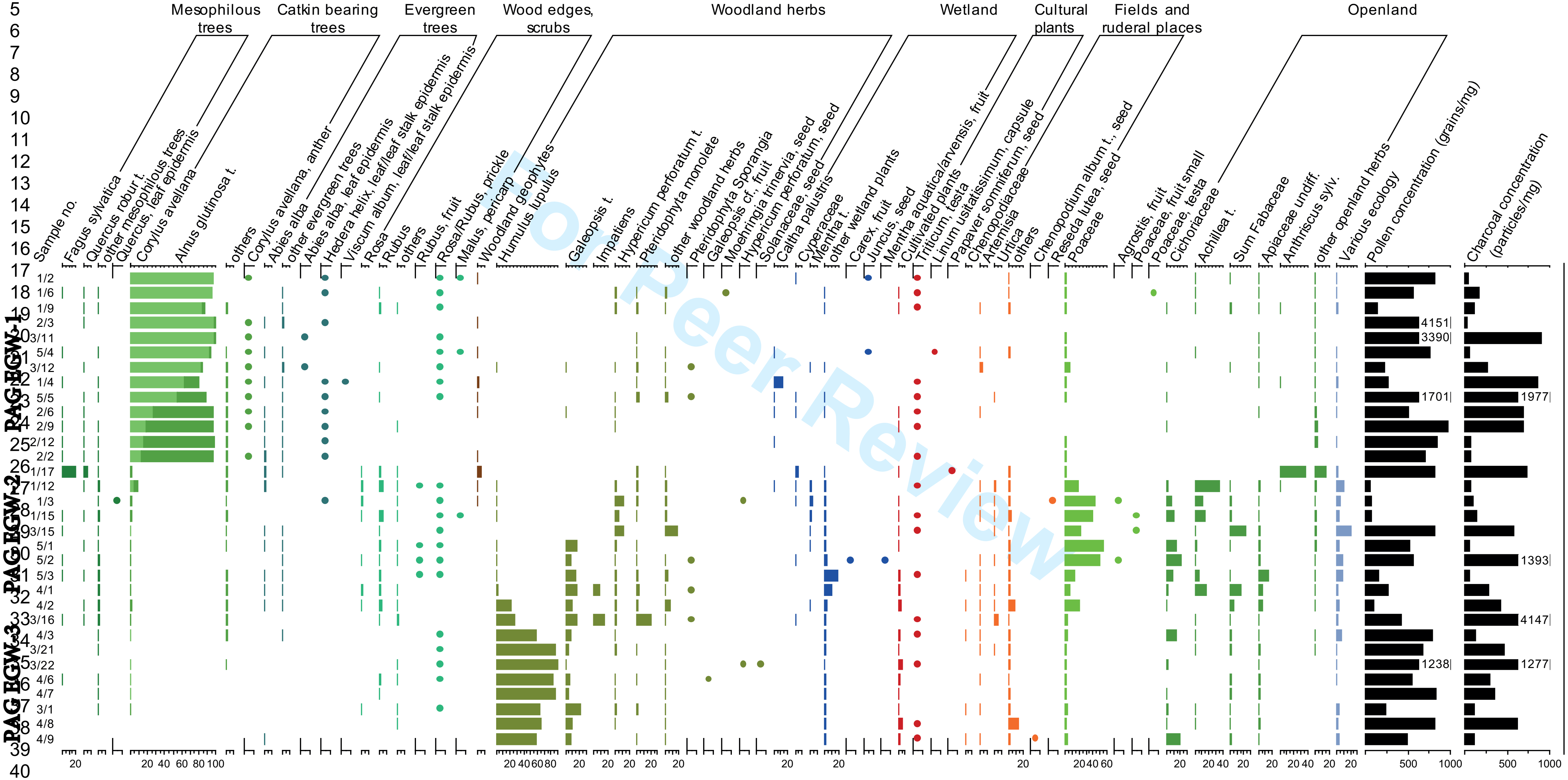
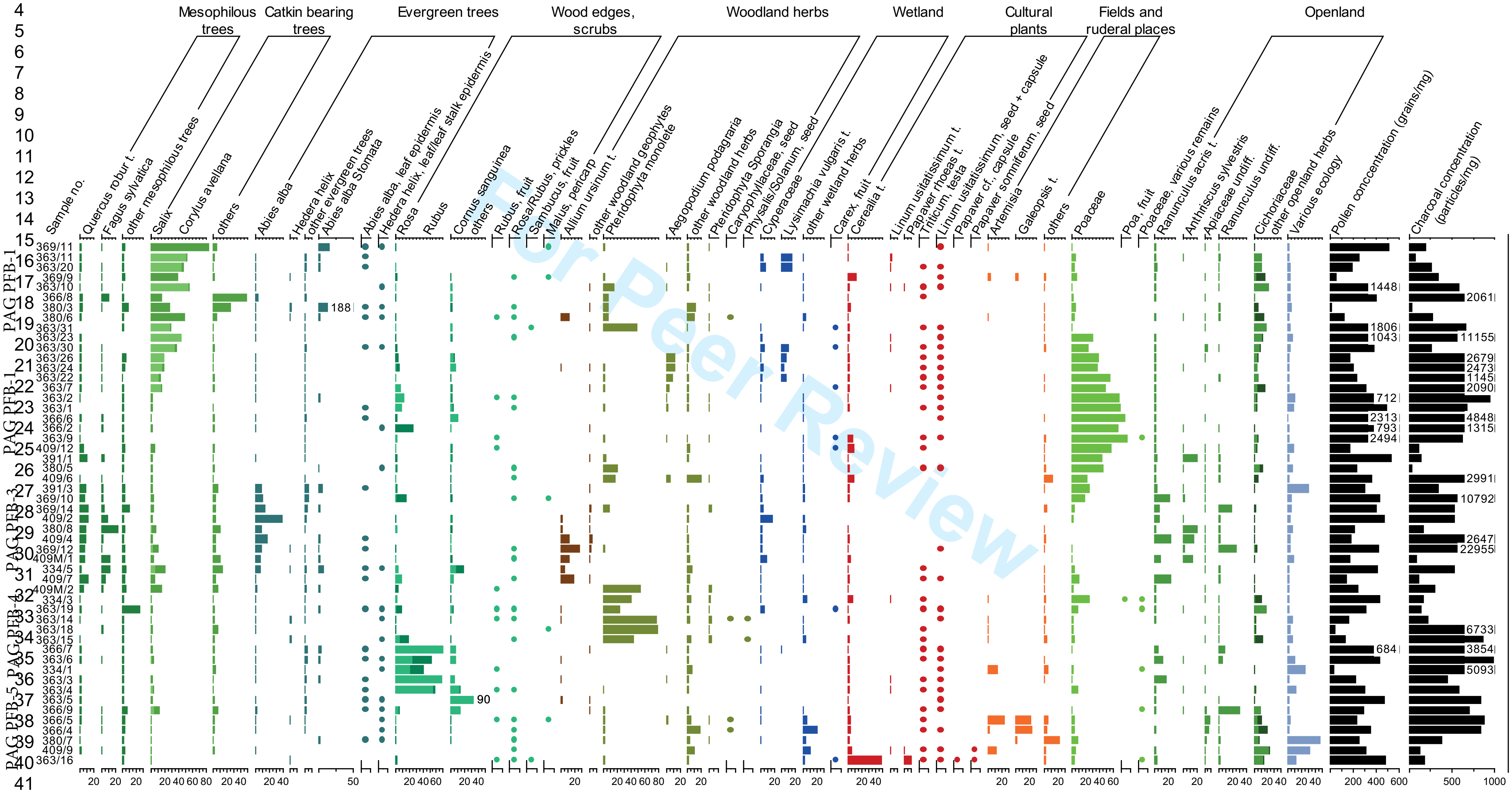


Figure 6. Presence of ruminant dung in the settlement layer of Zurich Parkhaus Opéra layer 13 (Horgen culture, 3175–3157 cal BC). Figure by F. Antolin. The photograph shows a goat/sheep dung piece (photograph by G. Haldimann, ©IPNA Basel University). For more details see Antolin et al., 2016 [in press].
254x190mm (72 x 72 DPI)


Mesophilous trees
Catkin bearing trees
Evergreen trees
Wood edges, scrubs
Woodland herbs
Wetland
Cultural plants
Fields and ruderal places
Openland
Sample no.
Fagus sylvatica
Quercus robur t.
other mesophilous trees
Quercus, leaf epidermis
Corylus avellana
Alnus glutinosa t.
others
Corylus avellana, anther
Abies alba
other evergreen trees
Abies alba, leaf epidermis
Hedera helix, leaf/leaf stalk epidermis
Viscum album, leaf/leaf stalk epidermis
Rosa
Rubus
others
Rubus, fruit
Rosa/Rubus, prickle
Malus, pericarp
Woodland geophytes
Humulus lupulus
Galeopsis t.
Impatiens
Hypericum perforatum t.
Pteridophyta monolete
other woodland herbs
Pteridophyta Sporangia
Galeopsis cf. fruit
Moehringia trinervia, seed
Hypericum perforatum, seed
Solanaceae, seed
Caltha palustris
Cyperaceae
Mentha t.
other wetland plants
Carex, fruit
Juncus, seed
Mentha aquatica/arvensis, fruit
Cultivated plants
Triticum, testa
Linum usitatissimum, capsule
Papaver somniferum, seed
Chenopodiaceae
Artemisia
Urtica
others
Chenopodium album t., seed
Reseda lutea, seed
Poaceae
Agrostis, fruit
Poaceae, fruit small
Poaceae, testa
Cichoriaceae
Achillea t.
Sum Fabaceae
Apiaceae undiff.
Anthriscus sylv.
other openland herbs
Various ecology
Pollen concentration (grains/mg)
Charcoal concentration (particles/mg)
PAG EGW-1
PAG EGW-2
PAG EGW-3
1/2
1/6
1/9
2/3
3/11
5/4
3/12
1/4
5/5
2/6
2/9
2/12
2/2
1/17
1/12
1/3
1/15
3/15
5/1
5/2
5/3
4/1
4/2
3/16
4/3
3/21
3/22
4/6
4/7
3/1
4/8
4/9
4151
3390
1701
1977
1393
4147
1238
1277
20
20 40 60 80 100
20 40 60 80
20
20
20
20
20
20
20
20
20 40 60
20
20 40
20
20
20 40
20
20
500 1000
500 1000


Mesophilous trees
Catkin bearing trees
Evergreen trees
Wood edges, scrubs
Woodland herbs
Wetland
Cultural plants
Fields and ruderal places
Openland
Sample no.
Quercus robur t.
Fagus sylvatica
other mesophilous trees
Salix
Corylus avellana
others
Abies alba
Hedera helix
other evergreen trees
Abies alba Stomata
Abies alba, leaf epidermis
Hedera helix, leaf/leaf stalk epidermis
Rosa
Rubus
Cornus sanguinea
others
Rubus, fruit
Rosa/Rubus, prickles
Sambucus, fruit
Malus, pericarp
Allium ursinum t.
other woodland geophytes
Pteridophyta monolete
Aegopodium podagraria
other woodland herbs
Pteridophyta Sporangia
Caryophyllaceae, seed
Physalis/Solanum, seed
Cyperaceae
Lysimachia vulgaris t.
other wetland herbs
Carex, fruit
Cerealia t.
Linum usitatissimum t.
Papaver rhoeas t.
Triticum, testa
Linum usitatissimum, seed + capsule
Papaver cf., capsule
Papaver somniferum, seed
Artemisia
Galeopsis t.
others
Poaceae
Poa, fruit
Poaceae, various remains
Ranunculus acris t.
Anthriscus sylvestris
Apiaceae undiff.
Ranunculus undiff.
Cichoriaceae
other openland herbs
Various ecology
Pollen conccentration (grains/mg)
Charcoal concentration (particles/mg)
PAG PFB-1
PAG PFB-1
PAG PFB-3
PAG PFB-4
PAG PFB-5
PAG PFB-
369/11
363/11
363/20
369/9
363/10
366/8
380/3
380/6
363/31
363/23
363/30
363/26
363/24
363/22
363/7
363/2
363/1
366/6
366/2
363/9
409/12
391/1
380/5
409/6
391/3
369/10
369/14
409/2
380/8
409/4
369/12
409M/1
334/5
409/7
409M/2
334/3
363/19
363/14
363/18
363/15
366/7
363/6
334/1
363/3
363/4
363/5
366/9
366/5
366/4
380/7
409/9
363/16
188
90
1448
2061
1806
1043
11155
2679
2473
1145
2090
712
2313
4848
793
1315
2494
2991
10792
2647
22955
684
3854
5093
6733
20
20
20
20 40 60 80
20 40
20 40
50
20 40 60
20 40
20
20 40 60 80
20
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20 40 60
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20
20 40
20 40
20 40
200 400 600
500 1000

Fig. 5, Jacomet et al.

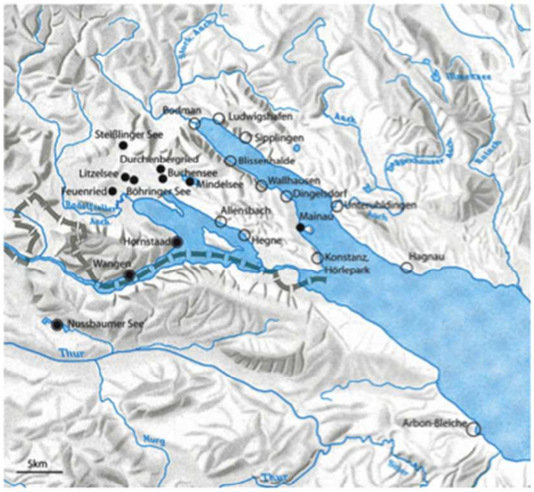


Figure 8. Location of the high-resolution pollen diagrams (black dots) in the western Lake Constance region (after Rösch et al., 2014, p. 122) (white squares represent archaeological sites with archaeobotanical investigations).
254x190mm (72 x 72 DPI)

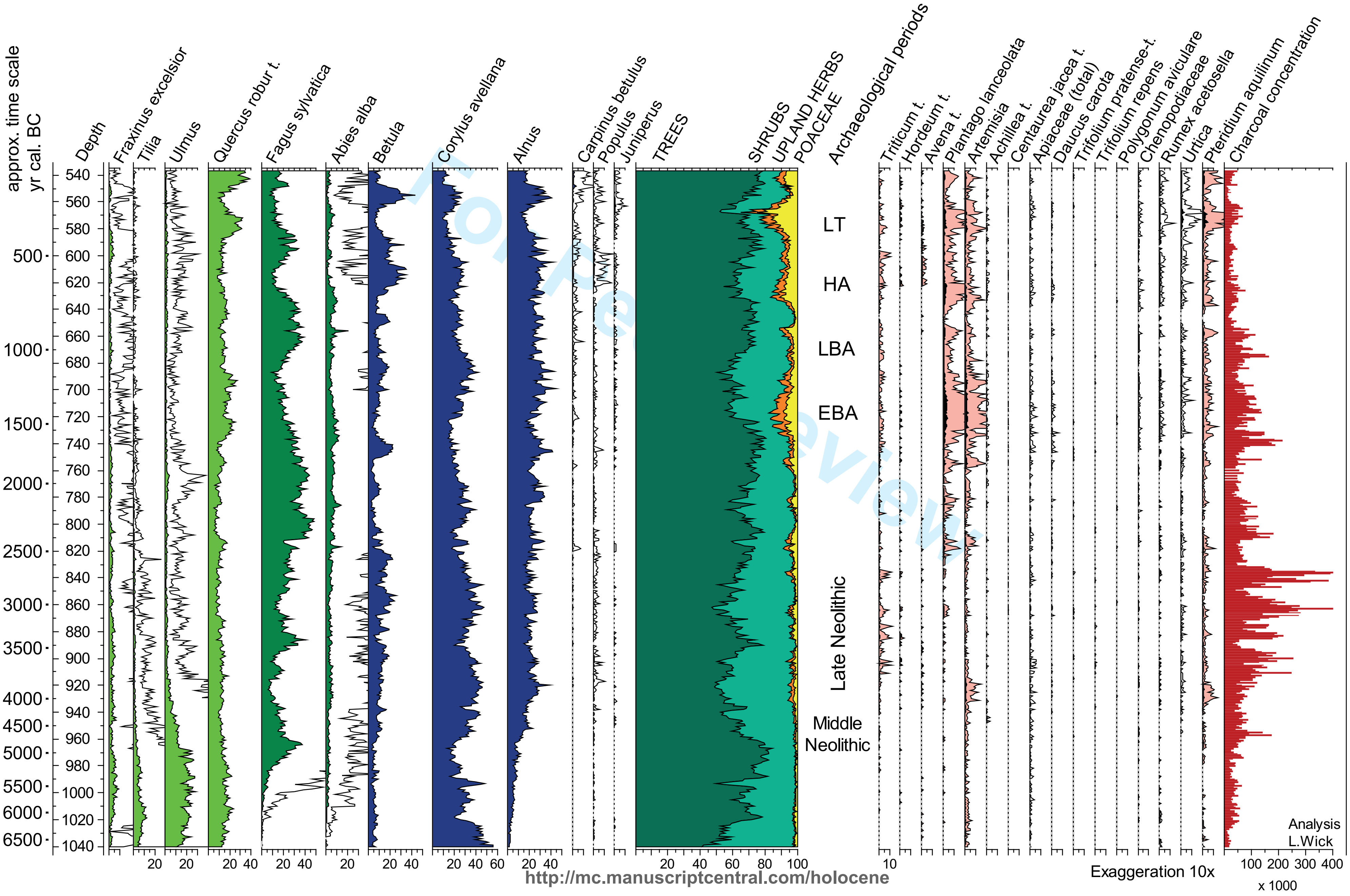
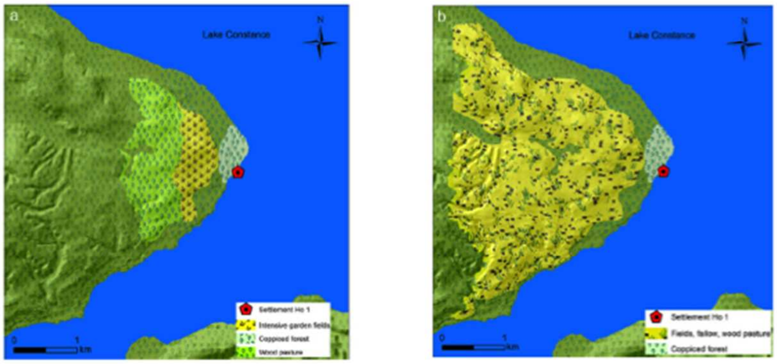

approx. time scale yr cal. BC
Depth
Fraxinus excelsior
Tilia
Ulmus
Quercus robur t.
Fagus sylvatica
Abies alba
Betula
Corylus avellana
Alnus
Carpinus betulus
Populus
Juniperus
TREES
SHRUBS
UPLAND HERBS
POACEAE
Archaeological periods
Triticum t.
Hordeum t.
Avena t.
Plantago lanceolata
Artemisia
Achillea t.
Centaurea jacea t.
Apiaceae (total)
Daucus carota
Trifolium pratense-t.
Trifolium repens
Polygonum aviculare
Chenopodiaceae
Rumex acetosella
Urtica
Pteridium aquilinum
Charcoal concentration
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
540
560
580
600
620
640
660
680
700
720
740
760
780
800
820
840
860
880
900
920
940
960
980
1000
1020
1040
LT
HA
LBA
EBA
Late Neolithic
Middle Neolithic
20
20
20 40
20 40
20
20 40
20 40 60
20 40
20 40 60 80 100
10
Exaggeration 10x
100 200 300 400
x 1000
Analysis
L.Wick

Fig. 3, Jacomet et al.



a) Intense cultivation b) Shifting cultivation

1

Figure 10. Possible amounts of open and shrubby land around a Late Neolithic settlement (Hornstaad-Hörnle I, Lake Constance, 3918–3905 cal BC). Modelling attempt based on a) permanent fields with intensive cultivation (left) and b) the existence of slash-and-burn cultivation (from Baum, 2014).
254x190mm (72 x 72 DPI)

On-site data cast doubts on the hypothesis of shifting cultivation in the Late Neolithic (c. 4300-2400 cal. BC). Landscape management as an alternative paradigm

Online Supplementary Materials (OSM): OSM text

Supplement to Introduction*:*

Whether or not the wetland sites mirror economically specialised settlements or socially marginalised groups is a matter of debate see e.g. Whittle, 1996, p. 216 ff.; Pétrequin et al., 2005). In the hinterland near the lakes only a few coeval settlements are known, but recent survey programmes show peaks of settlements and activities related to high settlement densities on the lake shores (e.g. Mauvilly and Boisaubert, 2005; dendroarchaeological studies also indicate such dense occupation, e.g. Billamboz, 2014). On the basis of archaeobotanical on-site data we do not see – at first sight – any difference in plant husbandry between lakeshore sites and the few hinterland settlements when taphonomic filters are taken into account (see e.g. Jacomet, 2013); this, however, has to be evaluated in greater detail.

State of research and interpretation tools

Off-site data

Off-site pollen data can be used as a proxy for the intensity of land use (Figure 2, print text). When considering the area discussed in this article we must mention in particular the ten (and more) high-resolution pollen diagrams that exist; these mostly come from sediments from the central part of small lakes in the western part of the area around Lake Constance investigated from the 1980s onwards by the research group around M. Rösch (for an overview see fig. 5 and table 7, p. 108 in Lechterbeck et al., 2014). This is currently the best-investigated area with regards to pollen analysis in Europe. The profiles are independently dated by more than 200 radiocarbon dates, and the time models have been carefully revised (by applying a Bayesian approach). The main aim of these studies was to reconstruct not only the vegetation history but also the type of human use of the landscape since the Neolithic. The places investigated lie mainly in the region of Upper Swabia, the western part of Lake Constance (Rösch et al., 2014) and the Hegau which is located somewhat further to the west (Lechterbeck et al., 2014; fig. 5).

In these bogs and (mostly small) lakes there was no evidence of direct human influence on deposition. The human impact of nearby settlements, however, has left traces in such sediments in the form of open-land pollen or micro-charcoal. As numerous investigations of the last decade have shown, it is rather complicated to reconstruct quantitatively from pollen data the degree to which the landscape was open or the type of use it was put to (see e.g. Sugita, 2007a; Sugita, 2007b; Broström et al., 2008; Hellmann et al., 2009; Gaillard et al., 2010; Trondman et al., 2014). The reason for this is that pollen data catch the amalgamate effects of a large number of partly unidentified processes on pollen rain. If there are no empirical actualistic data available as a basis for comparison, it seems impossible to reconstruct in detail specific single practices of unknown consequences from the sum of all the processes.

On-site data

The main aim of archaeobiological on-site investigations is to reconstruct the subsistence economy (Figure 2, print text). We define subsistence as 'all activities which are necessary to satisfy pure biological needs (not only food but also clothing and shelter) as well as essential social and spiritual requirements' (Jacomet and Schibler, 2010).

Generalities/Basics. Biological on-site data encompass the disciplines of archaeobotany and archaeozoology as well as dendrotypology (for definitions see Jacomet, 2007a, and Billamboz, 2014). Here we describe in greater detail the state of the art and the grounds on which interpretation are based because this is rarely found in the palaeoecological literature. We concentrate on wetland sites; indeed the sheer quantity of remains of wild and domesticated species and high resolution both in time and space on such sites can supply many empirical facts for the reconstruction of former land use.

The main difference between on- and off-site data is that the remains we investigate on human occupation sites (on-site data) are part of a sediment that is to a very large degree of anthropogenic origin. Human behaviour, the activities in a settlement in the past, belongs to the most important factors influencing the spectra of bioarchaeological remains in anthropogenic layers (so-called cultural transformation, after Schiffer, 1991; Schiffer, 2002; summarized in Jacomet, 2007a).

Examining on-site data is essential for establishing how the remains entered a given context and its formation processes (for basics, see e.g. Davis, 1987; Kreuz, 1990; Kreuz, 1995; Kreuz, 2012; Van der Veen, 2007; Jacomet, 2013). Remains from cultural layers represent a mixture of single events and accumulations of remains over longer periods of settlement activity, transformed by synchronous and later taphonomic processes.

We have to make sure that we do not take single events, which might be unrepresentative, as 'the average'. On the other hand, if we can reconstruct such single events, these can give extremely valuable information on specific activities or past plant assemblages (e.g. animal dung or uncleaned cereal stocks, see below). Detailed and representative intra-site investigations form the basis of any relevant synthesis (e.g. Jacomet and Brombacher, 2005; Antolin et al., 2015 [in press]).

Natural influences also play a role in layer formation (natural transformation *sensu* Schiffer, 1991; Schiffer, 2002): as lakeshore settlements were located in a highly dynamic environment – the lake shore – we can detect water influences or phases of drying out, or relocations (are remains *in situ* or not?), and there may also be signs of erosion or selective preservation (see e.g. Jacomet et al., 1989; Leuzinger, 2000; Ismail-Meyer et al. 2013, p. 331; Bleicher and Ruckstuhl, 2015). Bog settlements are less influenced by such natural factors, but there organic preservation is subject to other selection mechanisms (see e.g. Herbig, 2006). In general, the reasons why organic materials are well preserved in organic waterlogged layers are poorly understood (e.g. Bleicher and Schubert, 2015).

All these aspects show that the interpretation of on-site data is in no way straightforward and influenced by even more factors than off-site data. For interpretation we use several so-called 'middle range tools' (tools from contemporary situations such as the ecological values of weeds that help explain past situations; after Binford and Binford, 1968).

The numerous comprehensive archaeobiological investigations of the last decades have however made clear that the principle of 'uniformitarianism' (meaning 'the present is the key to the past') can often not be transferred to past situations when humans are involved.

Archaeobotany. Figure 3 in the print text shows the state of the archaeobotanical on-site research concerning the Neolithic lake dwellings in the vicinity of the Alps (for more details see Jacomet, 2006; Jacomet, 2007b; Jacomet, 2008; Jacomet, 2009; Herbig, 2009). In particular, plant macroremains like seeds, fruits, chaff or wood were investigated (here we do not treat on-site pollen data which are only available in small quantities).

Systematic research over the last forty years has yielded a large amount of macroremain data from over 100 settlement layers from all parts of the northern Alpine foreland (Figure 6 in the print text) as well as from other regions like Slovenia, see Tolar et al., 2011) and most of these data are stored in the ArboDat database (Kreuz and Schäfer, 2014).

A recent example of a comprehensively-sampled settlement layer is the Horgen cultural layer 13 of the Zürich-Parkhaus Opéra site (Bleicher and Harb, 2015), which is currently being examined (Figure OSM 4; Antolin et al., 2016 [in press]). In wetland settlement layers a much larger spectrum and a greater number of remains and taxa are present than in dryland sites (burnt layers may be an exception). It is mostly waterlogging that causes their preservation. For the methodology used in our investigations (sampling, recovery etc.) we refer to published works on this subject (e.g. Hosch and Zibulski, 2003; Jacomet and Brombacher, 2005; Vandorpe and Jacomet, 2007; Tolar et al., 2009; Antolin et al., 2015; Steiner et al., 2015).

In order to reconstruct environmental conditions we use the following 'middle range tools': besides ecological grouping, based on actualistic (modern or ethnographic) data (see Behre and Jacomet, 1991), we apply statistical methods like Spearman's rank correlation for finding correlations between, for example, wild plants and cultivated taxa (e.g. Hosch and Jacomet, 2004). The so-called 'closed assemblages', such as uncleaned cereal stocks which still contain the weeds that grew on the fields, constitute an important source of information. Their spectra can be evaluated in the way mentioned above. More recently, they were used in functional attribute studies aimed at reconstructing crop growing conditions and land management practices (Functional interpretation of Botanical Surveys or FIBS; Jones 2002; Bogaard 2004 and 2011; Bogaard et al., 2016); for explanations see below, chapter 'Results of on-site data: Evaluation of the weed spectra based on their life forms, other functional attributes and ecological demands'). Also very recently, isotope research (like ^{14}N/^{5}N) was carried out on the cereal grains found in such assemblages, which suggested that manuring took place (Bogaard, 2012; Bogaard and Outram, 2013; Bogaard et al., 2013).

Archaeozoology. The state of the art concerning archaeozoology is presented by Schibler (e.g. Schibler, 2006 and Schibler, 2016, [in press] and Figure 4, print text).

Data on hand-collected large bones (mostly mammals) from over 100 settlements are available. Archaeozoological (bone) data are also stored in a database (OSSOBOOK; Schibler, 1998; Kaltenthaler et al., 2015). Several overviews and evaluations, including basics of methodology, are published (see Schibler, 2006; Schibler, 2016 [in press] and citations there).

The state of research concerning small bones (mostly of birds, fishes and amphibians) or mussels, snails or insects, which are extracted from soil samples (often the same as those used for botanical macroremains) is at present less satisfactory but information on such kinds of remains, indicative, for example, of fishing techniques has nonetheless greatly improved over the last fifteen years (e.g. Hüster Plogmann, 2004; Lemdahl, 2004; Schmidt, 2011).

Dendrotypology. Dendrotypology is a dendroarchaeological approach that was developed from the 1980s onwards in parallel to pure dendrochronological dating (for a recent summary of the methodology and results from the western Lake Constance region see Billamboz, 2014). Dendrotypology rests on the classification of timber (based on the tree rings) according to tree age, growth patterns and the degree of stem conversion, which form the basis for creating dendro-groups. These provide an insight into the structure and dynamics of the forest stands that were exploited (from clearing activities and coppicing practices to forest degradation). In our investigation area such analyses have mainly been developed since the 1980s by A. Billamboz in the western Lake Constance region (Billamboz, 2014) and in Upper Swabia (primarily in the Federsee region; Bleicher, 2009); the situation is less satisfactory in the rest of Switzerland but is however improving (Suter and Francuz, 2010; Bleicher et al., 2013).

Other interpretation tools. As further interpretative tools we also use the results of experimental archaeology (such as experimental fields: Bogaard, 2002; Schier et al., 2013; Ehrmann et al., 2014) and ethnographic data (e.g. Charles et al., 2002; Smith, 2011a and b). In the latter case we must ensure that examples from similar climatic regions are used. Ethnographic data cited in the literature on Native North American forest communities and their abilities to shape a wooded landscape in temperate climate zones is most promising (e.g. Smith, 2009; Smith, 2011a; more indications of burning in the overview by Scherjon et al., 2015).

Results of on site-data: Basic aspects of animal and plant husbandry

During the Late Neolithic (hereafter LN), domestic animals and cultivated plants played an important role in the economy. Beside cattle, pigs and sheep as well as goats there were dogs too. In the LN, all these domestic animals continue to be important, in variable proportions (Schibler, 2006; Schibler, 2016 [in press]), with increasing herd sizes observed towards the end of the LN (Ebersbach, 2002; Schibler, 2006; see Figure 4, print text).

For overviews on the LN plant economy see Herbig, 2009; Jacomet, 2006; Jacomet, 2007b; Jacomet, 2008; Jacomet, 2009; Jacomet, 2014). The main cereals were different wheat taxa. Tetraploid naked wheat (*Triticum turgidum* s.l.[1]) and emmer (*Triticum dicoccum*) were the most important taxa, whereas einkorn (including two-grained *Triticum monococcum*) is quite rare and only locally important (e.g. Karg and Märkle, 2002). There were always considerable quantities of six-rowed barley (*Hordeum vulgare*). The other main cultivars were flax (*Linum usitatissimum*) and opium poppy (*Papaver somniferum*); pea (*Pisum sativum*) appears rarely in larger amounts. However, pea may be underrepresented; as the ongoing investigations on the Horgen culture layer 13 of Zürich Parkhaus-Opéra show: there are many fragments of subfossil pea pods, which may have been overlooked in earlier investigations (Antolin et al., 2016 [in press]). Although the quantification of plant remains represents a methodological challenge and the results are hypothetical, model calculations give us an idea that carbohydrate-rich sources were highly important to meet the daily demand for calories (Gross et al. 1990; Schibler and Jacomet, 2010; on the importance of gathered fruits, see below).

The reasons behind the change of the importance of cultivars in the course of the LN (Figure OSM 3) are not yet clear. A changing environment may have played a role, but also – and perhaps primarily – various cultural influences from the East or the West (see e.g. Jacomet, 2007b; Kreuz et al., 2014).

Results of on-site data indicative of the farming regime and landscape management, incl. difficulties in reconstructing the Late Neolithic weed flora

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[1] The nomenclature of scientific plant names for cultivars follows the traditional classification, after Zohary, Hopf and Weiss (2012).

For several reasons it is difficult to define what a weed was in LN times. As weeds are crucial for land-use reconstruction, the reasons for this are explained here:

Mostly mixed assemblages

The settlement layers of the LN lakeshore settlements are mixed assemblages containing the refuse from all kinds of different activities. Among others, there are hundreds of thousands of (mainly) chaff remains of cereals, but also capsule fragments of flax, pod fragments of pea or even capsule fragments of poppy, to a very large extent preserved in a subfossil state (for a new and up-to-date example see Antolin et al., 2016 [in press]). There is also a large variety of open-land taxa in the same samples; many of them can be attributed to the 'crop weeds' ecological group by actualistic grouping (see compilation in Brombacher and Jacomet, 1997, p. 258 ff.). Such a combination of cultivar remains and weed taxa reflects the typical refuse found in agrarian settlements, well comparable with, for example, refuse in Early Neolithic Linearbandkeramik (LBK) pits, although the latter is present in charred form only (see e.g. Kreuz, 2012).

Cleaning stages in mixed assemblages not clearly identifiable

For mixed refuse layers in lake-dwelling sites it is difficult to define the cleaning stages. If we compare the combination of remain types and taxa with ethnographic data (e.g. Hillman, 1984; Jones, 1987; Jones, 1990) we see that remains of winnowing and perhaps also sieving are present in the cultural layers, including the weeds (for an attempt, see Jacomet et al., 1989, p. 169). We therefore conclude that annual weed taxa which are still known as crop weeds today were also crop weeds in LN times. This is corroborated by statistical approaches (Spearman rank correlation; see Hosch and Jacomet, 2004, fig. 101, p. 130) conducted for the site of Arbon-Bleiche 3 (around 3380 cal. BC). There, some typical annual weeds (partly the same as those already considered to be weeds on the basis of actualistic approaches) but also some perennials showed a high degree of correlation with cultivars (Figure 5 in the print text; OSM Table 5).

Unknown (or hypothetical) processes before the harvest (tillage, weeding, harvesting methodology)

Tillage practice must have been different from what we know from ethnographic sources (for a thorough description of examples of the latter, see Kreuz, 2012).

There are no undisputable finds of ploughs (ards), the few known examples being far from straightforward to interpret (see Brombacher and Jacomet, 1997, p. 270); only hoe-like instruments are regularly found (see e.g. Leuzinger, 2002). Whether the ardmarks found in the eastern Alps (canton of Grisons, south-eastern Switzerland) can be dated to the Neolithic remains to be clarified (there are no ^{14}C data directly from the ard furrows; Rageth, 1992; Rageth and Defuns, 1992).

We do not know if weeding was practised. We can only assume it was carried out, based on assumptions and comparisons with, for example, present-day organic farming. As for harvesting techniques, we can take the growth heights of the weed taxa as an indicator, assuming that most of the weeds were harvested with the cereals. If weed seeds appear in stocks it is highly likely that they were harvested with the cereals; this is well known from ethnographic sources. Therefore, in archaeobotany, the height of the weeds is usually taken as an indication of the height of the harvest. If we can find large quantities of very low growing weeds (e.g. *Aphanes arvensis*), it is highly probable that cereals (for example) were cut very close to the ground. If we can only find high growing weeds, the culms were cut at some distance from the ground, and low growing weeds could not be harvested. In LN stocks, low growing weeds are generally present, so we must assume that harvest height was usually quite close to the ground.

Which proportion of the weeds is represented in storage contexts?

Undoubtedly the best basis for reconstructing the weed flora in LN times is the spectrum of wild plants appearing in storage contexts representing single events (the so-called closed assemblages). There are many different kinds of such storage contexts represented in lakeshore settlements, from ears stored in an uncleaned state to very well cleaned stocks in which only grains are present. A systematic evaluation of the cleaning stages of these stocks, based on the ethnographic data mentioned above, is unfortunately missing. Moreover, we cannot always exclude secondary mixing of materials during a conflagration when houses collapsed. Nevertheless, uncleaned or only party cleaned stocks are known from several settlements (see Figure 5 in the print text and OSM Table 5; e.g. Maier, 2001; Brombacher and Jacomet, 2003). In these, seeds of annual weeds in today's sense are regularly present, although in very different amounts (from zero to 15 taxa, from zero to more than 100 remains). There are however also a series of other taxa present in the stocks; these taxa are considered today to be ruderals, grassland plants, plants of woodland clearings etc.; in Neolithic times they must have been weeds too (see Figure 5 in the print text and OSM Table 5: 1–8 taxa and 0–50 remains; see tables in Brombacher and Jacomet, 1997, pp. 258–261; OSM Table 5).

Beside annuals perennials were also regularly present. The same – incidentally – holds true for the LBK fields of the loess landscapes (Kreuz and Schäfer, 2011), and is shown on Figure 5 in the print text and in OSM Table 5. The spectrum of wild plants known from storage contexts representing single events is eminently comparable with 'weedy' wild plant spectra in mixed samples (see Figure 5 in the print text and OSM Table 5).

One so far not mentioned reason for the difficulties to compare modern weed communities with Neolithic ones is that not all of today's weed species (the anthropochores) were present in Central Europe at the time (see e.g. Willerding, 1986; Jacomet and Brombacher, 2009; Kreuz, 2012) and therefore many opportunistic 'weedy' taxa, which today are more typical of forest fringes etc., had also spread onto the fields.

Results of on-site data: Evaluation of the weed spectra based on their life forms, other functional attributes and ecological demands

For an overview of 'traditional' evaluations based on ecological groups, life forms and Ellenberg indicator values (Ellenberg, 1991) we refer to Brombacher and Jacomet (1997, p. 256 ff.), Maier (2001) and Hosch and Jacomet (2004, p. 128 ff.). More recently, a novel type of evaluation method for weeds was introduced, the FIBS-approach (Functional Interpretation of Botanical Surveys) (see e.g. Jones (2002), Bogaard (2004), Bogaard (2011) and Bogaard et al. (2016)). 'This alternative approach uses functional attributes, which measure the ecological characteristics of weed species, and is not dependent on the co-occurrence of particular species or the reliability of field observations to indicate species preferences. Functional attributes permit the 'translation' of present-day ecological data to archaeobotanically attested species and, through an understanding of ecological processes, provide the means to disentangle the separate effects of different husbandry practices, so allowing the identification of novel combinations of practices in the past' (from Jones, 2002). FIBS was applied to assemblages from two sites only: the burnt cereal (mainly tetraploid naked wheat) stock layer of the settlement of Hornstaad-Hörnle IA (3910 cal. BC) and a similar layer containing a store of emmer from the settlement of Zurich-Mythenschloss dating to the period of the Corded Ware culture (around 2700 cal.

BC; Brombacher and Jacomet, 1997).

The most important results are briefly presented in the print text.

Hints on grazing the fallows

In the region of Zurich, one of the best investigated lakeshore areas, the weed spectrum shows an increase in the presence of plants growing on present-day grassland in the course of the LN (Figure OSM 5). This points to grazing the fallows or the stubble fields, which had the side-effect of manuring them (the same was noticed already in the early Neolithic LBK (LBK phase I to phase II; Kreuz, 2012). This also means that some parts of the landscape remained open for longer periods and suggests that there was a permanent and steady pressure on such places from both humans and animals. Here, but perhaps also in the floodplains, the first grassland plant communities may have developed during the third millennium cal. BC, in parallel with larger herd sizes (Figure OSM 2). This grassland is however not yet directly comparable with modern sown, manured and irrigated grassland.

Results of on-site data indicating opening the landscape for pastures and hunting/gathering grounds

Evidence based on denrotypology (types of woodland management)

By analysing large masses of timber used for building from the lakeshore villages it has become increasingly clear how dynamic the settlement pattern during the LN usually was: settlement phases were generally short (mostly five to seventeen years; for an overview see Bleicher, 2009, pp. 144–152). Longer settlement durations are documented only exceptionally. Often, the settlements move around within a certain region. Bleicher (2009) has reconstructed ten-year cycles of woodland management ('*Freistellungsreaktionen und Stockwaldphasen*') in two settlement areas in the surroundings of lake Federsee in Upper Swabia. There are, however, also locations to which people always came back, and therefore these regions were settled continuously for over 1000 years with only a few decades of interruption (like the Zurich region or Sipplingen on Lake Constance)

In some time periods young wood from coppices of managed woodland with short rotations of 10–20 years was used for building purposes. Abrupt growth changes in young oak tree ring series reflect successive coppice rotations (as seen for instance in the hinterland of Sipplingen on Lake Constance). On the other hand, in some periods (after longer breaks in settlement activity) natural forest stands with old-grown trees were felled, as at the beginnings of the Pfyn and Horgen cultural sequences in the western part of the region around Lake Constance (see Figure OSM 1 for chronology). There are clear indications that the settlements at the lake's shore were part of a larger system involving the hinterland where settlement occupation must have existed too (although very little is known of such occupation). In the final phases of the exploitation cycles there might be signs of land overuse and woodland degradation, especially towards the end of the Neolithic (e.g. Corded Ware phases in the western part of Lake Constance, although not visible in the N isotope record; see Styring et al., 2015).

For more details we refer to the recent compilation by Billamboz (2014) for the western part of Lake Constance, the supra-regional overview of Bleicher (2009, pp. 144–152) and to Suter and Francuz (2010) for the state of the art in western Switzerland. Ongoing analyses in the Zurich region show similar trends (Bleicher et al., 2013).

To conclude, there were evidently sophisticated cycles of woodland use in existence. A mosaic-like landscape in areas used for timber, but also as a source of leafy hay, pasture and wild fruits (see below) can be reconstructed (for an ethnographic example see Figure OSM 6).

Evidence based on ruminant dung

In wetland settlement layers, animal dung, mostly of ruminants (sheep/goat and cattle) is very often encountered (a very good example is shown on Figure 6 in the print text). It therefore seems clear that ruminants were kept inside the settlements, at least some of the time, for example for milking.

It also shows that there was at least some dung available, but its use cannot be reconstructed directly. Investigations of plant macro- and micro-remains (mainly pollen) in ruminant dung gave valuable indications on the surfaces on which the animals grazed (see Rasmussen, 1989; Rasmussen, 1993; own investigations include Akeret and Jacomet, 1997; Akeret et al., 1999; Akeret and Rentzel, 2001; Haas, 2004; Kühn and Hadorn, 2004; Kühn and Wick, 2010; Marinova et al., 2013; Kühn et al., 2013). So far mainly dung of small ruminants, goat and sheep, has been investigated (it is in fact indistinguishable). Two examples are shown on Figures 7a and 7b in the print text which are explained here more in detail:

Figures 7a and 7b include only the major taxa (i.e. quantitatively and/or ecologically significant), among them all the taxa with macrofossil finds. Pollen, spores, stomata, and fern sporangia are shown as percentages, related to the total sum of pollen and Pteridophyta spores. Pollen and micro-charcoal concentrations are given as grains or particles per mg of wet material. In order to facilitate the comparison of the micro- and macrofossil remains, the macroremains (dots, indicating presence/absence) are combined with the respective pollen taxa (bars) in the diagrams. The pollen taxa are summarized into groups representing different habitats (woodland, open land etc.) or fodder types (e.g. evergreen trees). The samples are arranged according to their pollen assemblages; the pollen assemblage groups (PAGs) represent different fodder types or natural habitats, respectively.

Figure 7a (print text): Pollen and macroremain diagram of Egolzwil 3 (Late Neolithic, 4260 cal. BC). 32 pellets were investigated for both, macroremains and pollen resp. microcharcoal.

Plant macroremains: Trees/shrubs are represented by regular finds of *Rosa*/*Rubus* prickles, leaf epidermis of *Hedera helix* and anthers of *Corylus avellana*. Fruits of *Rubus*, leaf epidermis of *Abies alba*, *Viscum album* and *Quercus* were found in lower frequencies. Herbs are represented by single finds of seeds/fruits or epidermis of a larger number of taxa, growing today on open land, ruderal and/or wet habitats (along ditches or in marshy areas). Cultivars are mainly represented by high quantities of *Triticum* testa. Remains of other cultivars were found in only small amounts.

Microremains: The pollen concentrations are generally high. Nearly all dung samples contained high amounts of micro-charcoal. The pollen spectra were divided into three pollen assemblage groups (PAG): PAG EGW-1 (13 samples; No. 1/2 to 2/2) shows a dominance of *Corylus* and/or *Alnus*, accompanied by woodland geophytes flowering in early spring. PAG EGW-2 (10 samples, No. 1/17 to 4/2) shows high percentages of Poaceae pollen in combination with taxa from woodland edges and open woodland like *Rosa*, *Rubus*, *Galeopsis*, and *Hypericum perforatum* type. PAG EGW-3 (9 samples, No. 3/16 to 4/9) is characterised by taxa growing in fresh and/or rather open woodland habitats, such as *Humulus lupulus*, *Impatiens*, *Galeopsis*, and Pteridophyta. Cereal pollen was found in most of the samples.

Figure 7b (print text): Pfäffikon Burg (Late Neolithic, 3100 cal. BC). 52 pellets were investigated for both, macroremains and pollen resp. microcharcoal.

Plant macroremains: Phanerophytes are represented by continuously occurring prickles of *Rosa*/*Rubus*, fruits of *Rubus* as well as regular finds of leaf epidermis of *Abies alba* and *Hedera helix*. Other trees/shrubs are rare (not shown on the diagram). Herbs of open land and/or fresh habitats are represented only by a rather small number of taxa, occurring in low frequencies. Remains of cultivars however are frequent, especially *Triticum* testa and flax remains. Sporangia of ferns were also found regularly.

Microremains: The pollen concentrations are generally high. Nearly all the samples show high quantities of micro-charcoals. The pollen spectra were assigned to five PAGs, pointing to a great variety of fodder sources in the landscape: PFB-1 (9 samples, No. 369/11 to 363/31) is dominated by *Salix* and *Corylus avellana*, with herbaceous taxa indicating grazing in open woodland and wetland, such as Pteridophyta and Cyperaceae. Pollen values of deciduous trees are generally low. PFB-2 (15 samples, No. 363/23 to 409/6) is characterised by very high percentages of Poaceae, accompanied by shrubs and herbs representing woodland edges, coppices and open land areas; other non-arboreal pollen (NAP) are rare. In PFB-3 (10 samples, No. 391/3 to 409/07) rather high percentages of mesophilous deciduous trees are combined with *Abies alba* pollen and stomata, and various amounts of *Corylus*, *Alnus*, and *Betula*. Among the NAP, Pteridophyta, *Allium ursinum* t., *Ranunculus acris* t., *Anthriscus sylvestris*, and Cyperaceae show higher values. PFB-4 (11 samples, No. 409M/2 to 363/4) shows a strong dominance of either Pteridophyta spores or shrub pollen (*Rosa*, *Rubus*) representing open woodland habitats. *Ranunculus acris* t. and *Anthriscus sylvestris* belong to the most frequent herb taxa. PFB-5 (7 samples, No. 363/5 to 363/16) is very poor in tree pollen and dominated by plants growing on fields and ruderal places, such as *Artemisia*, *Papaver rhoeas* t., and *Triticum* t. The lowermost sample 363/16 with the highest amount of Cerealia-type pollen contains only a low percentage of charcoal.

Evidence based on open-land-taxa (grassland, woodland edges etc.)

In general, we can see an increase in diversity but also the ubiquitous presence of open-land taxa in the course of the LN (see examples in Brombacher and Jacomet, 1997). Not only has the weed flora become more diverse (see above) but also other open-land communities have become more widespread. Domestic animals play once again an important role in this context. In the dung pieces mentioned above, there is much evidence for winter- and summer grazing and foddering of the ruminants in the vicinity of the settlement (see previous chapter for references). This is corroborated by the insect data (e.g. Lemdahl, 2004; Schmidt, 2011). There must have been quite extensive, heavily pastured surfaces close to the settlements. An attempt to model the grazing pressure based on the minimum number of individuals (MNI) of domestic animals at the settlement of Arbon-Bleiche 3 (around 3380 cal. BC) sows that 5–10 (minimum 2, maximum 13) km^2 around the settlement were needed to provide enough fodder for the herd (Jacomet et al., 2004, p. 399; for modelling attempts in the Zurich region see Ebersbach, 2003). There was, however, no grassland in today's sense in the LN. First grassland plant communities used for pastures and haymaking resembling modern grassland communities did not exist before the Late Bronze Age or even the Late Iron Age in Central Europe (see e.g. Körber-Grohne, 1990; Körber-Grohne, 1993; Willerding, 1999; Kreuz, 2005, p. 174 ff.; Jacomet and Brombacher, 2009, and fig. 5 there).

On what surfaces then did the animals browse? In the course of the LN we see an increase in the ubiquitous presence of some grassland taxa (macroremains; Figure OSM 5 shows 4 taxa as examples of the general trend.

It is mainly during the third millennium cal. BC that some kind of grassland-like plant communities became more important. This is corroborated by on-site pollen studies from the region of Zurich (Erny-Rodmann, 1995). However, whether these taxa really grew on grassland in today's sense, or were established, for instance, on grazed short-fallows or in open woodlands, is difficult to ascertain (another possibility may be beaver meadows in floodplains). Some of the taxa obviously grew on fields and fallows as the weed spectra show. In any case, this development goes hand in hand with increasing cattle herd sizes, which can be reconstructed on the basis of data from bone concentrations in occupation layers (Figure OSM 2; (Schibler et al., 1997: Synthesis) and is most probably a result of a rising grazing pressure that reached its maximum during the Corded Ware phases from 2800 cal. BC onwards. An intensification of woodland management practices like coppicing also played a role (see above). The appearance in the macroremain record of thorny plant species like juniper (*Juniperus*) or holly (*Ilex*), which became more widespread under high pasture pressure towards the later phases of the LN, is in good agreement with these observations (Brombacher and Jacomet, 1997, p. 277, table D359; corroborated by ongoing analyses in the Zurich region).

Off-site pollen data from the Mainau site (western Lake Constance) show rising micro-charcoal values in these periods (Figure 9 in the print text); this can be interpreted as a need to expand grazing areas by burning. The latter would support our contention that fire played a crucial role in shaping a more open landscape in the course of the LN.

Evidence based on gathering and hunting

In well-investigated LN settlement layers we can find over 100 species of wild plants, and most of them were useful in one way or another (see e.g. Jacomet et al., 1989; Antolin et al., 2015 [in press]). Not only did food for humans have to be provided by gathering, but also fodder (and pasture) for animals, and wood for constructions and firewood (for the latter see e.g. Dufraisse, 2008), as well as bast fibres etc. (as an example see Jacomet et al., 2004: Synthesis). Human food in the form of fruits rich in starch and fat (like hazelnuts, acorns and beechnuts) and vitamins (like rose hips, raspberries, wild strawberries, crab apples) appears in huge quantities in LN settlement layers. The waterlogged preservation of the layers is one of the reasons why gathered fruits are so well represented in lakeshore settlements (Jacomet, 2013; Colledge and Conolly, 2014). There is plenty of evidence that such fruits were indeed eaten because human faeces rich in such fruits are documented (see e.g. Maier, 2001). Some are also found in crusts inside pots: they were cooked.

It is however hard to quantify what proportion of the calories was provided by hunted and gathered food. On the basis of a well-sampled, recently-investigated cultural layer from Zürich Parkhaus-Opéra (layer 13; the dendrochronological dating indicates that the village was occupied for just over twenty years from 3176 to 3153 cal. BC; Bleicher and Harb, 2015 [in press]), we think that gathered foods in the nutrition could have provided up to 20% of the calories (Figure OSM 7; Antolin et al., 2015 [in press]). Accumulations of gathered food, e.g. hazelnut shells, were also present in the rubbish heaps of Zürich Parkhaus-Opéra (layer 13). This and many examples from other LN wetland settlements show that hazelnuts were always important in the nutrition. At Hornstaad-Hörnle I the settlement including the whole of that year's harvest burnt down in 3910 cal. BC (Maier, 2001); in the layer directly above this burnt layer there is a layer full of hazelnut shells, which suggests that hazelnuts also served as an important staple in times of need. In many settlements there are stocks with gathered plants (e.g. Gachnang-Niederwil or Hornstaad-Hörnle 1A; van Zeist and Boekschoten-van Helsdingen, 1991; Maier, 2001). We can even put forward the hypothesis that fruit-bearing shrubs and trees (and probably also valuable annuals; Schlichtherle, 1981) were tended to achieve higher productivity. It would otherwise not have been possible to collect their fruits in large amounts, as represented by tens of thousands of remains (for details see Antolin et al., 2015 [in press]). In addition to providing calories gathered plants also had the important role of providing vitamins and microelements (see Kreuz, 2012).

In order to create landscapes suitable for a good yield in gathered wild plants we consider opening and keeping the landscapes open by burning to be a good strategy. This hypothesis is well supported by ethnographic sources. Burning was widespread to create good gathering grounds, e.g. among Native North American forest communities which in some ways were intermediate between farmers and hunter-gatherers (see Smith's 2001 'low level food production'; or 'niche construction', e.g. Kendal et al., 2011; Smith, 2011a). For more examples from different parts of the world we refer to Scherjon et al. (2015). It must however be borne in mind that burning the landscape is a characteristic of hunter-gatherer groups whereas the LN communities were clearly farmers.

Burning may also have played an significant part in creating better hunting and browsing grounds since in several phases of the LN, hunting was important for the provision of food (Schibler, 2016 [in press]). This may hold for whole settlements or only for parts of them as investigations in Arbon-Bleiche 3, for example, have shown for the period around 3380 cal. BC (Deschler-Erb and Marti-Grädel, 2004). Good hunting grounds in the surroundings of the settlements must indeed have been of crucial importance. Larger areas of open land and a well-structured landscape are also the reason why animals like hare or red fox become increasingly important in the course of the LN (mean percentages of bones rise from almost zero to well above 2–3% or even more; see figs. 10 and 11 in Jacomet and Schibler 2006).

Results of off-site data concerning opening the landscape and landscape management

The woodland in the western part of Lake Constance was dominated by *Fagus sylvatica* and other broad-leaved trees like *Quercus, Tilia*, *Ulmus* or *Acer* (e.g. Rösch 2013; Rösch et al., 2014; Lechterbeck, 2013; Lechterbeck et al., 2014). During land-use phases of the fourth and early third millennium cal. BC, several phases in which *Fagus* decreased strongly are visible in the many high-resolution pollen diagrams from there. In parallel there is an increase in secondary forest elements such as *Corylus* and *Betula*. This is interpreted as a replacement of the *Fagus*-dominated woodland by semi-open/shrubby vegetation, probably also coppiced forests, at the beginning of the LN. At the same time an increase of micro-charcoal (fluctuating curves) indicates woodland burning. During the strongest land-use phases of the LN, the natural woodland was in some places almost completely replaced by shrubs and coppiced forest; there are cases where the *Fagus* pollen curve declines from more than 30% to less than 10%, and a decrease in *Tilia* and *Ulmus* is also visible. The *Quercus* curve does not show such fluctuations, possibly because some oak trees were tended for a good yield in acorns.

Human impact is clearly visible in regions where settlements are located nearby (Lechterbeck et al., 2014, p. 109, mentions the Hornstaad and Mainau profiles). NAP and cereals also occur in higher values (Figure 9 in the print text). When settlements are located further away such impact is less visible (described as short episodes of forest disturbances with compensation by secondary forest elements – namely hazel and birch). Although agriculture is indicated by cereal pollen, a large increase of NAP and especially *Plantago lanceolata* is not recorded (as in the Luttersee profile near an Early Neolithic LBK settlement near Göttingen or in the later Corded Ware and Bell Beaker phases in the western Lake Constance region). Cereal pollen is usually rare. All this is interpreted as follows: extensive open land such as grazed forests, pastures, meadows or fallow land with strong pollen emissions of Poaceae, *Plantago lanceolata* and other wind-pollinated herbs did not exist.

An attempt by Lechterbeck (2013) to apply the models developed by the POLLANDCAL network (Sugita, 2007a; Sugita, 2007b; Gaillard et al., 2010) to reconstruct quantitatively the land cover for the western Lake Constance region in the older phase of the LN (4200–3700 cal. BC) on the basis of the results from two small lakes, Buchensee and Steisslinger See (the latter in the Hegau, more than 20 km to the west of Lake Constance) is not further considered here as the results concerning woodland/shrubby vegetation cover do not differ from the effects mentioned above. In addition, only one model (the slash-and-burn model) was used to reconstruct the land use and the results are therefore unbalanced.

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List of illustrations and legends
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OSM figures

Figure OSM 1. Chronological table with the cultural groups mentioned in the text. Abbreviations. MK=Michelsberger Kultur; LBK=Linearbandkeramik; SOB = Südostbayerisches Mittelneolithikum; Br-O=Brubach Oberbergen (from Jacomet, 2007b). In the region considered here there are Early and Middle Neolithic cultural groups, and the transition Mesolithic-Neolithic can be roughly placed into the sixth millennium cal BC.

Figure OSM 2. Development of herd sizes in the course of the Late Neolithic, based on densities (concentrations) of hand-collected animal bones (numbers per layer volume and settlement duration). After Schibler, 1997.

Figure OSM 3. The changing importance of cultivated plants during the Late Neolithic, based on roughly quantified data, showing their approximate importance. Only settlements with some kind of representative sampling and more than around 500 cereal remains are shown. Numbers in bold indicate years cal BC. Figure by S. Jacomet, published in Suter, 2008, p. 345.

Figure OSM 4. House plans and surface sampling of the settlement Zürich Parkhaus Opéra layer 13 (Horgen culture, 3175–3157 cal BC). For more details of features see Bleicher and Ruckstuhl, 2015 [in press]. Figure after Antolin et al., 2015 [in press].

Figure OSM 5. Ubiquity of some grassland taxa and changes in the course of the Late Neolithic (based on waterlogged seeds). Figure S. Jacomet.

Figure OSM 6. Heavily utilised woodland (mainly for coppicing); Nemrut Dagi, Southern Turkey (photograph S. Jacomet, June 2009).

Figure OSM 7. Example of the ubiquitous presence of gathered plants in Late Neolithic lakeshore layers: densities (remains per litre of sediment, displacement volume) of subfossil hazelnut shells in Zurich Parkhaus Opéra layer 13 (Horgen culture, 3175–3157 cal BC). Figure by F. Antolin.

OSM Tables

OSM Table 1. List of wetland sites investigated by archaeobotany. For their location (numbers) see Figure 3 in the print text.

OSM Table 2. Bibliographic references to OSM Table 1.

OSM Table 3. List of wetland sites investigated by archaeozoology (large, hand-collected bones). For their location (numbers) see Figure 4 in the print-text.

OSM Table 4: Bibliographic references to OSM Table 3.

OSM Table 5. List of weedy taxa found in Neolithic stocks of cereals and flax, and wild plants growing on experimental fields (more explanations in the text). Archaeobotanical data are based on Maier, 2001; Brombacher and Jacomet 1997; Brombacher and Jacomet 2003; Kreuz 2012. Experimental data from Rösch et al. 2002.

BC cal	Southern France	Jura (Franche Comté)	Western Switzerland	Upper Rhine area (south) and Neckar region	Central Switzerland	Eastern Switzerland and Lake Constance	Upper Suabia incl. Federsee	Bavaria and Western Austria	Eastern Austria	BC cal	phases (Lüning 1996)	phases (Driehaus 1960)	
2200										2200	**Endneolithikum (Latest phase of the Late Neolithic)**		**Spätneolithikum**
2300	Campaniforme									2300		jüngeres	
2400			Campaniforme	Glockenbecher	Glockenbecher	Glockenbecher	????	Glockenbecher	Glockenbecher	2400			
2500		Chalain								2500			
2600	Fontbouisse		Auvernier Cordé *Auvernier*	Schnurkeramik	Schnurkeramik	Schnurkeramik		Schnurkeramik	Schnurkeramik	2600		**Endneolithikum**	
2700						?	Goldberg III			2700	**Spätneolithikum (middle phase of the Late Neolithic)**		
2800		Clairvaux récent	Lüscherz		spätes Horgen	spätes Horgen			Mödling-Zöbing (Jevišoviče)	2800			
2900				Goldberg III					Baden	2900			
3000		Clairvaux ancien Ferrières	*spätes Lattrigen* Horgen occidental *mittl. Lattrigen*	?	*jüng. Horgen*			Cham	Kostolac	3000		älteres	
3100	Ferrières				östliches Horgen *älteres Horgen*	Mittleres Horgen	Horgen	Ice Man (Ötzi)	Ossarn	3100			
3200		Horgen				Älteres Horgen				3200			
3300			Port Conty *frühes Lattrigen*		*frühes Horgen* Übergang Pfyn/Horgen	ältestes Horgen Übergang Pfyn/Horgen				3300			
3400	Néolithique récent	Port Conty		Munzingen B Munzingen B			????	Altheim / Mondsee	Boleráz	3400			
3500		Néolithique Moyen Bourguignon récent		(MK VI)	*jüng. ZH-Seefeld* Pfyn *ält. ZH-Seefeld* Pfyn/Cortaillod	jüngeres Pfyn				3500	**Jungneolithikum (Early phase of the Late Neolithic)**	**Jungneolithikum**	
3600			spätes Cortaillod	MK V Munzingen A			Pfyn/Altheim Ödenahlen			3600			
3700				MK IV		mittleres Pfyn			Bajč-Retz	3700			
3800	Chasséen méridional	Néolithique Moyen Bourguignon	*mittl. Cortaillod*	Schussenried	klassisches zentralschweiz. Cortaillod *jüng. ZH-Hafner*	älteres Pfyn				3800			
3900			klassisches Cortaillod	Entzheim B MK III		Hornstaad			Bisamberg	3900			
4000					frühes zentralschweiz. Cortaillod *ält. ZH-Hafner*	Lutzengüetle	Schussenried	Polling		4000			
4100		Néolithique Moyen Bourguignon ancien	*frühes Cortaillod*	MK II			?	Wallerfing	???	4100			
4200				Entz-heim A, Br-O MK I Schwie-berdin-gen						4200			
4300			älteres Cortaillod *Proto-Cortaillod*		Egolzwil	Kugelbecher-Gr.	Aichbühl	Münchshöfen		4300			
4400		?		Kugelbecher Gr. Bisch-heim Bisch-heim					IV	4400	**Mittelneolithikum (Middle Neolithic)**	**Mittelneolithikum**	**Frühneolithikum**
4500										4500			
4600	?			Rössen		Rössen			Lengyel or MOG	4600			
4700			Précortaillod		Mittelneolithikum		Mittelneolithikum	Oberlauterbach or SOB		4700			
4800									I	4800			
4900	Epicardial			Grossgartach m. Stichbandkeramik		Grossgartach m. Stichbandkeramik			Stichbandkeramik	4900			
5000				Hinkelstein				Stichbandkeramik		5000	**Früh- /Altneolithikum (Early Neolithic)**	**Altneolithikum**	
5100	Cardial franco-ibérique									5100			
5200			Néolithique Ancien (La Hoguette)							5200			
5300				LBK	Altneolithikum	LBK	Altneolithikum	LBK	LBK	5300			
5400	?									5400			
5500	Impressa									5500			
5600										5600			
5700										5700			

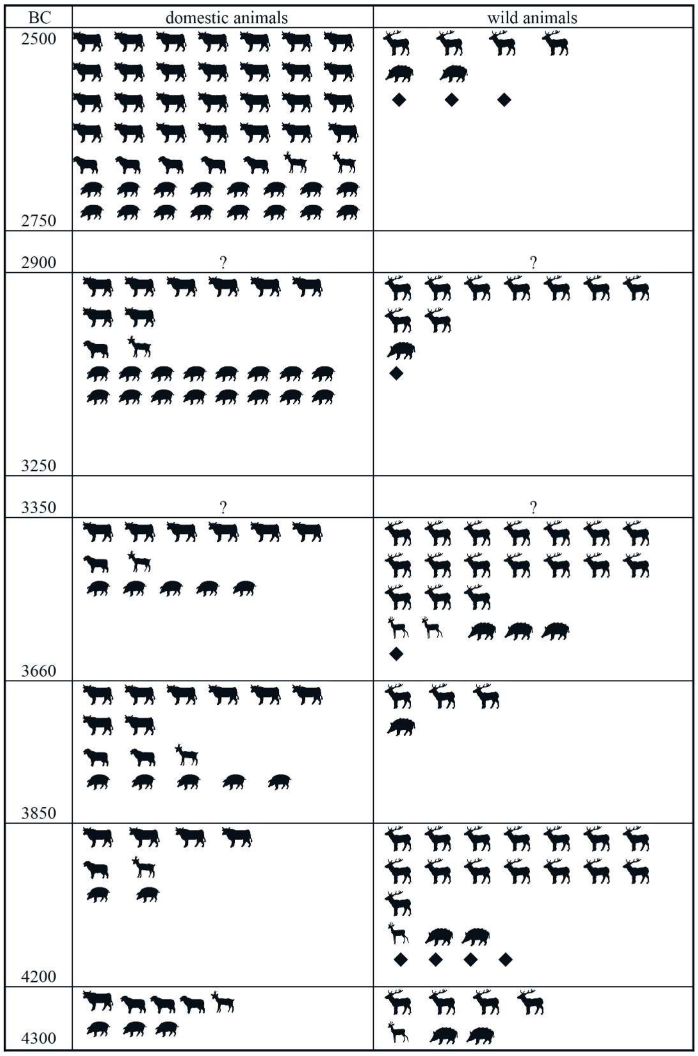

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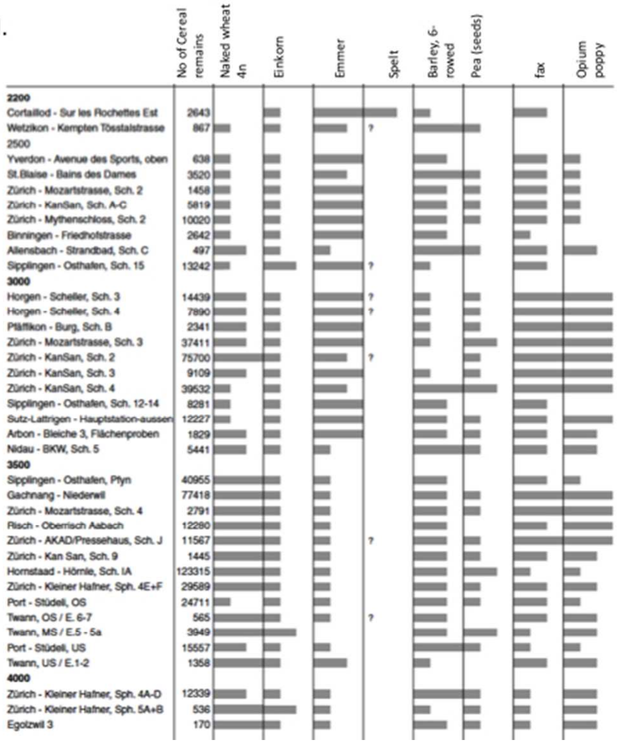
Fig. 10, Jacomet et al.



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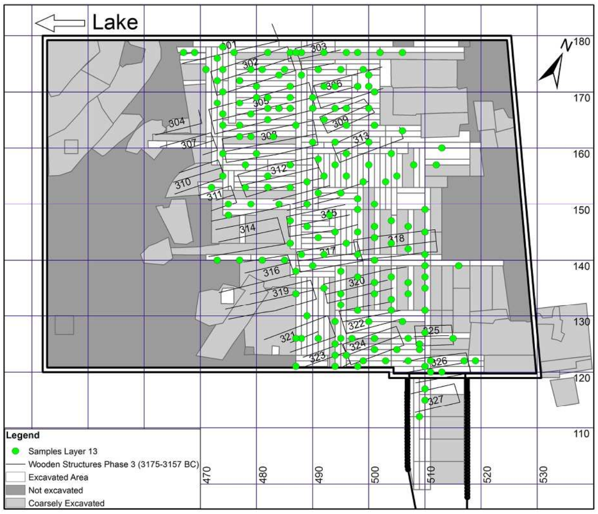

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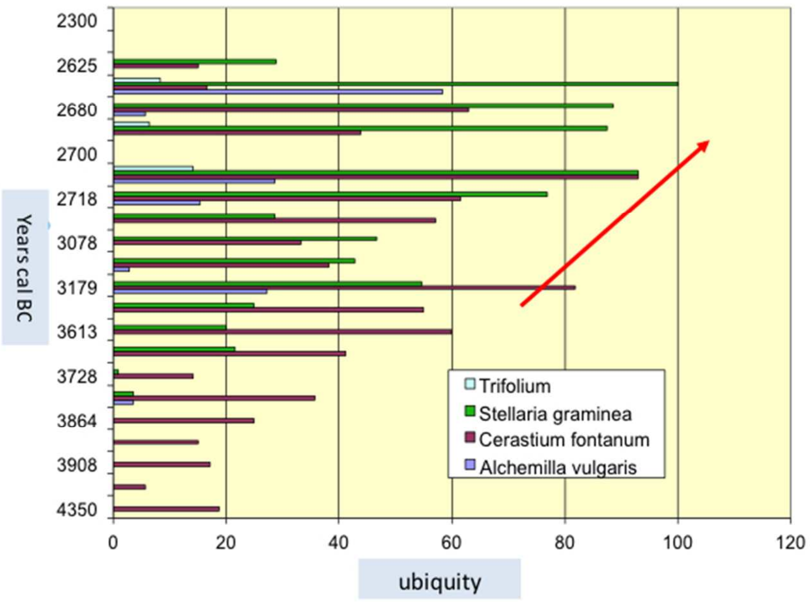
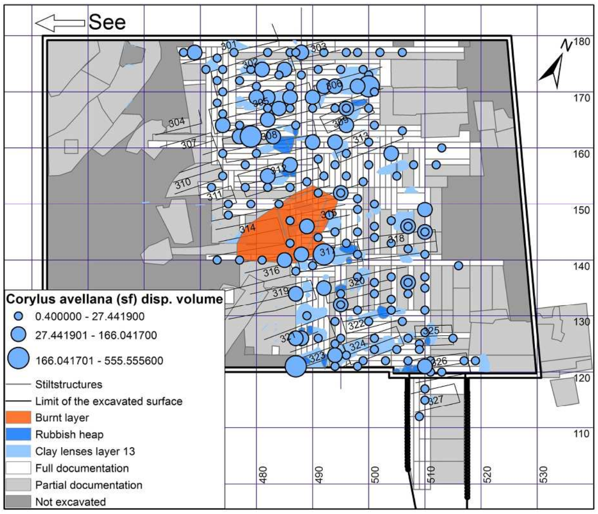
Fig. 12, Jacomet et al.



254x190mm (72 x 72 DPI)

722x541mm (72 x 72 DPI)



209x148mm (300 x 300 DPI)

site / settlement (after numbers on map Fig. 3; within one site / region: after dating). Swiss sites not specified with country-code	Number on map Fig. 3	Dendro Date (earliest or approx.)	culture (see Fig. OSM 1)	Publication of archaeobotanical data
Chalain (F) station 19, Schichten H-K	1	3050	Clairvaux Ancien	Schaal 2000
Chalain (F) station 3, Schicht VIII	1	3198	Horgen	Baudais et al. 1997
Clairvaux (F) II	1	3470	Port Conty	Lundstrom-Baudais 1989a, b
Clairvaux (F) III, Schichten II und III (u und m)	1	2975	Clairvaux récent	Lundström-Baudais 1986
Clairvaux (F) V Motte Aux Magnins	1	3659	Néolithique Moyen Bourguignon récent	Lundstrom-Baudais 1989c
Yverdon VD Avenue des Sports m (13/14-10, Schlichtherle-Profil)	2	2730	Auvernier Cordé, früh	Schlichtherle 1985; Wolf 1993
Yverdon VD Avenue des Sports o (9a-2 Schlichtherle Profil)	2	2600	Auvernier Cordé	Schlichtherle 1985; Wolf 1993
Yverdon VD Avenue des Sports u (Schi 16-14, Schlichtherle-Profil)	2	2750	Lüscherz récent	Schlichtherle 1985; Wolf 1993
Concise VD Sous Colachoz AUC (Häuf.-Klass.)	3	2699	Auvernier Cordé	Karg & Märkle 2002
Concise VD Sous Colachoz COC (Häuf-Klass.!)	3	3868	Cortaillod Classique	Karg & Märkle 2002
Concise VD Sous Colachoz COM (EMS (Konz.))	3	3709	Cortaillod-Moyen, Ens. 2	Märkle 2000; Karg & Märkle 2002
Concise VD Sous Colachoz COM (EMT grob analys. (Konz!))	3	3709	Cortaillod-Moyen, Ens. 2	Märkle 2000; Karg & Märkle 2002
Concise VD Sous Colachoz COT1 (Häuf.-Klass!)	3	3666	Cortaillod tardif	Karg & Märkle 2002
Concise VD Sous Colachoz COT2 (Häuf.-Klass.)	3	3567	Cortaillod tardif	Karg & Märkle 2002
Auvernier NE Brise-Lames	4	2792	Lüscherz	Baudais-Lundström 1978
St.Blaise NE Bains des Dames (Auv. Cordé Anc.)	6	2700	Auvernier Cordé Ancien	Mermod 2007
St.Blaise NE Bains des Dames (Auv. Cordé Moy.)	6	2600	Auvernier Cordé Moyen	Mermod 2007
St.Blaise NE Bains des Dames (Lüscherz)	6	2900	Lüscherz récent	Mermod 2007
Twann BE mittl. Horgener KS	7	3176	Horgen occidental (Lattrigen, spätes)	Piening 1981
Twann BE MS (E3-4)	7	3702	Cortaillod tardif	Ammann et al. 1981
Twann BE MS (E5 - 5a)	7	3643	Cortaillod tardif	Ammann et al. 1981
Twann BE OS (6-7)	7	3596	Cortaillod tardif	Ammann et al. 1981
Twann BE OS (E8-9)	7	3536	Cortaillod tardif	Ammann et al. 1981
Twann BE US, E1-2	7	3838	Cortaillod classique	Ammann et al. 1981
Lüscherz BE Kleine Station XV, Schn. 1-3	8	3410	Horgen occidental (Lattrigen, frühes)	Brombacher 1997
Sutz BE Lattrigen VI, Riedstation	9	3410	Horgen occidental (Lattrigen, frühes)	Brombacher 1997
Sutz BE Lattrigen, Hauptstation VII, aussen	9	3203	Horgen occidental (Lattrigen, spätes)	Brombacher 1997
Port BE Stüdeli, OS	10	3572	Cortaillod, spätes	Brombacher & Jacomet 2003
Port BE Stüdeli, US	10	3686	Cortaillod, spätes	Brombacher & Jacomet 2003
Nidau BE Schlossmatte BKW Ib, Schicht 5	11	3406	Horgen occidental (Lattrigen, frühes)	Brombacher 1997, 2000, sowie Hafner und Suter 2000
Seeberg BE Burgäschisee-Süd	12	3760	Cortaillod, klass. Zentralschweizerisches bzw. Zürich Hafner	Villaret-von Rochow 1967
Egolzwil LU 3, Wauwiler Moos	13	4282	Egolzwiler K.	Bollinger 1994a und b
Risch ZG Oberrisch, Aabach,	14	3710	Pfyner K. bzw. Zürich-Seefeld	Jacomet, unpublished data
Cham ZG Eslen	15	4225	Egolzwil/frühes zs. Cortaillod bzw. Zürich Hafner	Martinoli & Jacomet 2002; Brombacher, in prep.
Cham ZG St. Andreas	15	3700	Pfyn (-Cortaillod?)	Jacomet 1986
Zug ZG Riedmatt	near 16	3100	Horgener K.	Jacomet & Antolin 2010 (unpublished report)
Oberrieden ZH Riet	near 18	3300	Horgener K., früh	Jacomet 2004
Zug ZG Vorstadt 26, Rössliwiese	17	3050	Horgener K.	Jacomet & Wagner 1987
Horgen ZH Dampfschiffsteg	18	3713	Pfyner K.	Pawlik & Schweingruber 1976
Horgen ZH Scheller 3	18	3061	Horgener K.	Favre 2001, 2002
Horgen ZH Scheller 4	18	3078	Horgener K.	Favre 2001, 2002
Zürich Mozartstrasse Schicht 2	19	2625	Schnurkeramik	Jacomet, Brombacher, Dick 1989
Zürich KanSan Schicht A	19	2675	Schnurkeramik	Brombacher & Jacomet 1997
Zürich Mythenschloss Schicht 2	19	2680	Schnurkeramik	Jacomet, Brombacher, Dick 1989
Zürich KanSan Schicht B/C	19	2685	Schnurkeramik	Brombacher & Jacomet 1997
Zürich KanSan Schicht D	19	2705	Schnurkeramik	Brombacher & Jacomet 1997
Zürich KanSan Kreuzstr. B,D **(nur Getreide)**	19	2718	Schnurkeramik	Brombacher & Jacomet 1997
Zürich KanSan Schicht E (F?)	19	2718	Schnurkeramik	Brombacher & Jacomet 1997
Zürich AKAD/Pressehaus, Schicht C2	19	2719	Schnurkeramik	Jacomet-Engel 1980; Brombacher & Jacomet 1997
Zürich KanSan Schicht 2A	19	2911	Horgener K.	Brombacher & Jacomet 1997
Zürich Parkhaus Opéra Schicht 14	19	3090	Horgener K.	Antolin et al. 2015; Antolin et al. 2016
Zürich KanSan Schicht 2	19	3126	Horgener K.	Brombacher & Jacomet 1997
Zürich Mozartstrasse Schicht 3	19	3126	Horgener K.	Jacomet, Brombacher, Dick 1989
Zürich Parkhaus Opéra Schicht 13	19	3165	Horgener K.	Antolin et al. 2015; Antolin et al. 2016
Zürich KanSan Schicht 3	19	3179	Horgener K.	Brombacher & Jacomet 1997

site / settlement (after numbers on map Fig. 3; within one site / region: after dating). Swiss sites not specified with country-code	Number on map Fig. 3	Dendro Date (earliest or approx.)	culture (see Fig. OSM 1)	Publication of archaeobotanical data
Zürich KanSan Schicht 4	19	3239	Horgener K.	Brombacher & Jacomet 1997
Zürich Mythenschloss Schicht 3	19	3240	Horgener K.	Jacomet, Brombacher, Dick 1989; Brombacher & Jacomet 1997
Zürich KanSan Schicht 5	19	3616	Pfyner K. bzw. Zürich-Seefeld	Brombacher & Jacomet 1997
Zürich Mozartstrasse Schicht 4 u,m,o	19	3668	Pfyner K. bzw. Zürich-Seefeld	Brombacher & Jacomet 1997
Zürich Mozartstrasse Schicht 4 Pfyn B	19	3714	Pfyner K. bzw. Zürich-Seefeld	Brombacher & Jacomet 1997
Zürich KanSan Schicht 7 (=AKAD J)	19	3719	Pfyner K. bzw. Zürich-Seefeld	Brombacher & Jacomet 1997
Zürich AKAD/Pressehaus, Schicht J	19	3728	Pfyner K. bzw. Zürich-Seefeld	Jacomet 1981; Jacomet et al.1989; Brombacher & Jacomet 1997
Zürich Kan San Schicht 9	19	3827	Pfyn/Cortaillod-Üb. bzw. Zürich Hafner	Brombacher & Jacomet 1997
Zürich Mozartstrasse Schicht 5 u,o	19	3880	Cortaillod, klass. Zentralschweizerisches bzw. Zürich-Hafner	Jacomet, Brombacher & Dick 1989; Brombacher & Jacomet 1997
Zürich Mozartstrasse Schicht 6	19	3908	Cortaillod, klass. Zentralschweizerisches bzw. Zürich-Hafner	Jacomet et al. 1989; Brombacher & Jacomet 1997
Zürich Kleiner Hafner Schichten 4E/F	19	3968	Cortaillod, klass. Zentralschweizerisches bzw. Zürich-Hafner	Jacomet, Brombacher & Dick 1989; Brombacher & Jacomet 1997
Zürich Kleiner Hafner Schichten 4A-C/D	19	4185	Cortaillod, frühes zentralschweizerisches bzw. Zürich-Hafner	Jacomet, Brombacher & Dick 1989; Brombacher & Jacomet 1997
Zürich Kleiner Hafner, Schichten 5A+B	19	4384	Egolzwiler K.	Jacomet, Brombacher & Dick 1989; Brombacher & Jacomet 1997
Pfäffikon ZH Burg	21	3100	Horgener K.	Zibulski 2010
Gachnang TG Niederwil	23	3659	Pfyner K.	van Zeist & Boekschoten-van Helsdingen 1991
Pfyn TG Breitenloo	near 23	3708	Pfyner K.	Karg in Leuzinger 2007
Thayngen SH Weier, Sch. 16-19, Profil III	24	3822	Pfyner K.	Jörgensen 1975, Fredskild 1978
Arbon TG Bleiche 3 Flächenproben	26	3384	Pyn/Horgener K.	Hosch 2003; Hosch und Jacomet 2004
Arbon TG Bleiche 3 Profilproben	26	3384	Pyn/Horgener K.	Brombacher und Hadorn 2004
Wangen (D) Hinterhorn Kr. Konstanz	27	3371	Horgener K.	Riehl 1993 and Riehl unpublished manuscript
Hornstaad (D) V südl. Pfahlfeld	28	3176	Horgener K.	Rösch 1990a
Hornstaad (D) V nördl. Pfahlfeld Kr. Konstanz	28	3400	Horgener K.?	Rösch 1990a
Hornstaad (D) Hörnle IB Kr. Konstanz	28	3586	Pfyner K.	Maier unpublished data
Hornstaad (D) Hörnle II, Kr. Konstanz	28	3869	Pfyner K.	Rösch 1985
Hornstaad (D) Hörnle IA Kr. Konstanz	28	3917	Pfyner K. (Hornstaader Gr.)	Maier 2001
Allensbach (D) Strandbad ob. Schicht C	29	2829	Horgener K.	Karg 1990
Allensbach (D) Strandbad unt. Schicht B	29	3150	Horgener K.	Karg 1990
Bodman (D) Blissenhalde Kr. Konstanz	30	3600	Pfyner K.	Rösch 1987
Bodman (D) Weiler I	30	2900	Horgener K.	Herbig 2009 a and b
Sipplingen (D) Osthafen, Bodenseekreis, Schicht 16B	32	2860	Horgener K.	Maier 2010 (in Billamboz et al., 2010, FS Schlichtherle) and Maier in prep.
Sipplingen (D) Osthafen, Bodenseekreis, Schicht 15	32	2900	Horgener K.	Herbig 2009b
Sipplingen (D) Osthafen, Bodenseekreis, Schicht 16A	32	2900	Horgener K.	Maier 2010 (in Billamboz et al., 2010, FS Schlichtherle) and Maier in prep.
Sipplingen (D) Osthafen, Bodenseekreis, Schicht 15 = o	32	2917	Horgener K.	Jacomet 1990; Maier in prep.
Sipplingen (D) Osthafen, Bodenseekreis, Schicht 12-14 = u/m	32	3200	Horgener K.	Jacomet 1990; Maier in prep.
Sipplingen (D) Osthafen, Bodenseekreis, Schicht 13-14	32	3200	Horgener K.	Herbig 2009b
Sipplingen (D) Osthafen, Bodenseekreis, Schicht 11 = u	32	3316	Horgener K.	Jacomet 1990
Sipplingen (D) Osthafen, Bodenseekreis, Schichten 7-9	32	3700	Pfyner K.	Maier 2010 (in Billamboz et al., 2010, FS Schlichtherle) and Maier in prep.
Sipplingen (D) Osthafen, Bodenseekreis, Schicht 9	32	3706	Pfyner K.	Riehl 2004; Maier in prep.
Sipplingen (D) Osthafen, Bodenseekreis, Schicht 3	32	3900	Pfyner K.	Herbig 2009b
Sipplingen (D) Osthafen, Bodenseekreis, Schicht 1	32	3919	Pfyner K. (Hornstaader Gr.)	Maier 2010 (in Billamboz et al., 2010, FS Schlichtherle) and Maier in prep.
Sipplingen (D) Osthafen, Bodenseekreis, Schicht 2	32	4000	Pfyner K. (Hornstaader Gr.)	Herbig 2009b; Maier in prep.
Unteruhldingen (D) Bayenwiesen Befund 1020	33	3000	Horgener K.	Herbig 2009b
Unteruhldingen (D) Bayenwiesen Befund 0940	33	3300	Horgener K.	Herbig 2009b
Wallhausen (D) Ziegelhütte, Kr. Konstanz	35	3350	Horgener K.	Rösch 1990b
Wallhausen (D) Ziegelhütte, Kr. Konstanz	35	3750	Pfyner K.	Rösch 1990b
Alleshausen (D) Täschenwiesen, Kr. Biberach	36	2900	Goldberg III	Herbig 2009 a and b
Olzreute (D) Enzisholz III, Kr.	36	2900	Horgen/Goldberg 3	Herbig 2009 a and b
Schreckensee (D) G III Schichten	36	2900	Goldberg III	Herbig 2009 a and b
Alleshausen (D) Grundwiesen, Kr. Biberach	36	2916	Goldberg III	Maier 2004
Seekrich (D) Achwiesen, Kr. Biberach	36	2916	Goldberg III	Maier 2004
Königseggsee (D)	36	3000	Horgen	Herbig 2009b
Seekirch (D) Stockwiesen, Kr. Biberach	36	3030	Horgen/Goldberg III, Üb.	Maier 2004
Torwiesen II (D) Bad Buchau, Kr. Biberach	36	3283	Horgener K.	Herbig 2002, 2006
Torwiesen II (D) Bad Buchau, Kr. Biberach	36	3283	Horgener K.	Maier 2011
Bad Buchau (D) Dullenried	36	3300	Horgen	Herbig 2009 a and b

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Egg (D) Obere Güll 1	36	3300	Horgener K.	Herbig 2009b
Oedenahlen (D) Riedwiesen, Kr. Biberach	36	3700	Pfyn/Altheim	Maier 1995
Schreckensee (D) Pfyn-Altheimer Schichten	36	3700	Pfyn-Altheim	Herbig 2009 a and b
Reute (D) Schorrenried Kr. Ravensburg	36	3738	Pfyn/Altheim	Hafner 1998
Alleshausen (D) Hartöschle Kr. Biberach	36	3920	Schussenrieder K.	Maier 2004
Degersee (D)	36	4000	Schussenrieder K./Pfyner K. (Hornstaad-Gr.)	Herbig 2009b
Bad Buchau (D) Bachwiesen 1	36	4100	Schussenrieder K.	Herbig 2009 a and b
Hegne (D) Galgenacker Kr. Konstanz	near 29	2672	Schnurkeramik	Rösch 1990c
Maurach (D) Ziegelhütte, Befund 520	near 33	2500	Schnurkeramik	Herbig 2009b
Maurach (D) Ziegelhütte, Befund 540	near 33	2700	Schnurkeramik	Herbig 2009 a and b
Meersburg (D) Ramsbach	near 33	2900	Horgener K.	Herbig 2009 a and b
Nussdorf (D) Strandbad	near 33	3200	Horgener K.	Herbig 2009b
Litzelstetten (D) Ebenewiesen	near 35	2600	Schnurkeramik	Herbig 2009b
Litzelstetten (D) Krähenhorn I	near 35	4000	Pfyner K. (Hornstaader Gr.)	Herbig 2009 a and b
Litzelstetten (D) Krähenhorn II	near 35	4000	Pfyner K. (Hornstaader Gr.)	Herbig 2009 a and b
Staad (D) Hohenegg, Schicht 4	near 35	3000	Horgener K.	Herbig 2009 a and b
Staad (D) Hohenegg, Schicht 3	near 35	3300	Horgener K.	Herbig 2009b
Staad (D) Hohenegg, Schicht 2	near 35	3800	Pfyner K.	Herbig 2009b
Staad (D) Hohenegg, Schicht 1	near 35	3900	Pfyner K.	Herbig 2009b
Charavines (F) Dép. Isère	not on map	3000	CSR	Bocquet, Caillat & Lundstrom-Baudais 1986
Ehrenstein (D) Kr. Ulm, Phasen I-III	not on map	3955	Schussenrieder K.	Hopf 1968
Montilier FR Strandweg (Lac Morat)	not on map	3900	Cortaillod classique	Jacquat 2005
Pestenacker (D) Kr. Landsberg, Phasen I-III	not on map	3496	Altheimer K.	Neef 1991, Bittmann unpublished manuscript 1999, Bittmann 2001
Stansstaad NW Kehrsiten (Lake Lucerne)	not on map	3480 / 3448	Pfyn (late) / Horgen (early)	Brombacher in prep. (mentioned in Tobler 2010, see Billamboz et al., 2010, FS Schlichtherle)
Stansstaad NW Kehrsiten (Lake Lucerne)	not on map	?	Cortaillod	Brombacher in prep. (mentioned in Tobler 2010, see Billamboz et al., 2010, FS Schlichtherle)

Table OSM 2

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BCcal		Western and central Switzerland			Eastern Switzerland	
	No.	Settlements	References	No.	Settlements	References
	8	St. Blaise Bains des Dames H	Stopp unp. (IPAS)			
2500	8	St. Blaise Bains des Dames G	Stopp unp. (IPAS)			
	8	St. Blaise Bains des Dames F	Stopp unp. (IPAS)			
	8	St. Blaise Bains des Dames E	Stopp unp. (IPAS)	40	Zürich Mythenschloss 2.1	Hüster-Plogmann/Schibler 1997
	8	St. Blaise Bains des Dames Auv.	Stopp unp. (IPAS)			
				40	Zürich Mozartstrasse 2 oben	Hüster-Plogmann/Schibler 1997
2600	7	Auvernier La Saunerie	Stampfli 1976b	40	Zürich Mozartstrasse 2 unten	Hüster-Plogmann/Schibler 1997
				40	Zürich Mythenschloss 2.2-3	Hüster-Plogmann/Schibler 1997
	19	Sutz Lattrigen Rüt1e S5	Marti-Grädel in prep. (IPAS)	40	Zürich Seefeld Kan.San. A	Hüster-Plogmann/Schibler 1997
	19	Sutz Lattrigen Rüt1e S1	Marti-Grädel in prep. (IPAS)	40	Zürich Mythenschloss 2.4	Hüster-Plogmann/Schibler 1997
				40	Zürich Seefeld Kan.San. C/B	Hüster-Plogmann/Schibler 1997
	17	Vinelz Alte Station NW MS+OS	Marti-Grädel in prep. (IPAS)	40	Zürich Seefeld Kan.San. D	Hüster-Plogmann/Schibler 1997
2700	19	Sutz Lattrigen Rütte S2+3/F6+7	Marti-Grädel in prep. (IPAS)	40	Zürich Pressehaus C2	Hüster-Plogmann/Schibler 1997
	17	Vinelz Alte Station NW US	Marti-Grädel in prep. (IPAS)	40	Zürich Seefeld Kan.San. E	Hüster-Plogmann/Schibler 1997
	18	Lüscherz Dorf, Äussere Station OS	Marti-Grädel in prep. (IPAS)			
	17	Vinelz Hafen KS 1-3	Marti-Grädel in prep. (IPAS)			
	18	Lüscherz Dorf, Äussere Station US	Marti-Grädel in prep. (IPAS)			
	16	Biel Vingelz-Hafen	Marti-Grädel in prep. (IPAS)			
	11	Thielle Wavre, Pont-de-Thielle	Chaix 1977	40	Zürich Seefeld Kan.San. F	Hüster-Plogmann/Schibler 1997
	7	Auvernier Brise-Lames	Desse 1976			
	4	Yvonand 4	Clutton-Brock 1990	38	Zug Sennweid S4	Vellart/Fischer in prep.
	3	Yverdon Garage Martin 11-12	Chaix 1976 b			
2800	8	St. Blaise Bains des Dames 7	Stopp unp. (IPAS)	40	Zürich Kleiner Hafner 2A-D	Schibler 1987a
	18	Lüscherz-Fluh	Marti-Grädel in prep. (IPAS)			
	17	Vinelz Grabung Strahm 1960	Stampfli 1965/66			
	17	Vinelz Strandboden Schnitt 16	Marti-Grädel in prep. (IPAS)	38	Zug Sennweid S5	Vellart/Fischer in prep.
2900				54	Bodmann Weier II	Steppan 2012
	21	Nidau BKW 3	Glass/Schibler 2000			
3000				44	Meilen Rohrenhaab 2	Sakellaridis 1979
				46	Pfäffikon Burg C	Ebersbach et al. 2010
				43	Feldmeilen Vorderfeld 1x	Schibler/Veszeli 1998
				43	Feldmeilen Vorderfeld 1y	Schibler/Veszeli 1998
				46	Pfäffikon Burg B	Ebersbach et al. 2010
				41	Horgen Scheller 3	Ebersbach 2002
				40	Zürich Seefeld Kan.San. 2	Hüster-Plogmann/Schibler 1997
				40	Zürich Pressehaus E	Hüster-Plogmann/Schibler 1997
				41	Horgen Scheller 4	Ebersbach 2002
	15	Twann OH	Stampfli 1980	46	Pfäffikon Burg A	Ebersbach et al. 2010
				40	Zürich Mozartstrasse 3 oben	Hüster-Plogmann/Schibler 1997
3100				40	Zürich Mozartstrasse 3 allg.	Hüster-Plogmann/Schibler 1997
				40	Zürich Mozartstrasse 3 unten	Hüster-Plogmann/Schibler 1997
	9	Portalban Les Grèves	Chaix et al. 1983	43	Feldmeilen Vorderfeld 1z	Schibler/Veszeli 1998
	8	St. Blaise Bains des Dames 9	Stopp unp. (IPAS)	38	Zug Schützenmatte	Chaix 1989
	18	Lüscherz Binggeli	Marti-Grädel in prep. (IPAS)	40	Zürich Mythenschloss 3	Hüster-Plogmann/Schibler 1997
	14	La Neuville-Chavannes	Marti-Grädel in prep. (IPAS)	40	Zürich Pressehaus G	Hüster-Plogmann/Schibler 1997
	15	Twann MH	Stampfli 1980	40	Zürich Seefeld Kan.San. 3	Hüster-Plogmann/Schibler 1997
3200	20	Lattrigen VII aussen	Marti-Grädel in prep. (IPAS)	40	Zürich Kleiner Hafner 3A+B	Schibler 1987a
				40	Zürich Seefeld Kan.San. 4	Hüster-Plogmann/Schibler 1997
				43	Feldmeilen Vorderfeld 3	Schibler/Veszeli 1998
3300						
				43	Feldmeilen Vorderfeld 4	Schibler/Veszeli 1998
	20	Lattrigen VI	Glass/Schibler 2000	58	Arbon Bleiche	Deschler-Erb/Marti-Grädel 2004
3400	15	Twann UH	Stamplfi 1980			
	21	Nidau BKW 5	Glass/Schibler 2000	34	Stansstasd Kehrsitten	Michel-Tobler et al. 2010; Rehazek unp. (IPAS)
3500						
	15	Twann E9	Becker/Johansson 1981			
	15	Twann E8	Becker/Johansson 1981			
	22	Port Stüdeli OS	Stampfli/Schibler/Hüster-Plogmann 2003	38	Zug Vorstadt total	Rehazek/Schibler 2012
	7	Auvernier Port III	Chaix 1985			
	5	Consice E6	Chiquet 2012			
	19	Sutz Lattrigen VII innen	Kerdy unp. (IPAS)			
	3	Yverdon Garage Martin 14-16b	Chaix 1976b			
	15	Twann E7	Becker/Johansson 1981	52	Steckborn Schanz	Markert 1985
	15	Twann E6	Becker/Johansson 1981			
3600	3	Yverdon Garage Martin 18-20	Chaix 1976b	40	Zürich Seefeld Kan.San. 5	Hüster-Plogmann/Schibler 1997
				40	Zürich Mozartstrasse 4 oben	Hüster-Plogmann/Schibler 1997
	15	Twann E5a	Becker/Johansson 1981	40	Zürich Mozartstrasse 4 mitte	Hüster-Plogmann/Schibler 1997
	15	Twann E5	Becker/Johansson 1981	40	Zürich Mozartstrasse 4 unten	Hüster-Plogmann/Schibler 1997
	5	Consice E4A	Chiquet 2012			
	5	Consice E3B	Chiquet 2012			
	15	Twann E4	Becker/Johansson 1981	44	Meilen Rohrenhaab 3	Sakellaridis 1979
	22	Port Stüdeli US	Stampfli/Schibler/Hüster-Plogmann 2003	50	Gachnang Niederwil	Clason 1991
	5	Consice E2B	Chiquet 2012			
	15	Twann E3	Becker/Johansson 1981	40	Zürich Seefeld Kan.San. 6	Hüster-Plogmann/Schibler 1997

No.	Settlements	Refernces	Dating
75	Sion-Sous les Scex	Chaix/Sidi Maamar 1993	2700-2500BC
64	Untervaz-Haselbodensenke	Braschler unp. (IPAS)	2800-2400BC
69	Cazis-Petrushügel	Primas 1985	3200-3000BC
62	Eschen-Lutzengüetle	Hartmann-Frick 1959	3200-3000BC
65	Tamins-Crestis	Primas 1979	3200BC
64	Untervaz-Haselboden	Braschler unp. (IPAS)	3300-3200BC
75	Sion-Sous les Scex	Chaix/Sidi Maamar 1993	3700-3450
77	Collombey-Barmaz I	Chaix 1976	3700-3450BC
75	Sion-St. Guérin	Chaix 1976	3700-3450BC
73	St. Léonard-Sur le Grand Pré	Chaix 1976	3700-3450BC
71	Raron-Heidnischbühl	Chaix 1976	3700-3450BC
61	Schellenberg-Borscht	Hartmann-Frick 1964	3800-3700BC
62	Eschen-Lutzengüetle	Hartmann-Frick 1959	3800-3700BC
75	Sion-Petit Chasseur II	Chaix 1976; Gallay/Chaix 1984	3900-3700BC
62	Eschen-Lutzengüetle	Hartmann-Frick 1959	4000BC
31	Mumpf-Chapf	Braschler/Schibler 2009	4100-3900BC
75	Sion-Avenue Ritz	Chenal-Velarde 2002	4200-4000BC
63	Sevelen-Pfeffersbühl	Ebersbach	4300-4000BC
61	Schellenberg-Borscht	Hartmann-Frick 1964	4500BC
75	Sion-Tourbion	Chaix unp.	4900-5000BC
75	Sion-Planta	Chaix/Ginestet et al. 1987	5000BC
	dry land Neolithic		

Dating	No.	Settlement	References	Taphonomy
Late Bronze Age	56	Hagnau D-Burg, 7-12	Kokabi 1990	Wetland
	56	Hagnau D-Burg, 2-6	Kokabi 1990	Wetland
	12	Hauterive NE-Champréveyres C 3	Studer 1991; Borello/Chaix 1983	Wetland
	47	Greifensee ZH-Böschen 2007	Veszeli/Hüster Plogmann 2007; Schibler 1987b	Wetland
	40	Zürich ZH-Grosser Hafner	Schibler unp. (IPAS)	Wetland
	39	Zug ZG-Sumpf	Schibler 1996b	Wetland
	40	Zürich ZH-Alpenquai	Wettstein 1924	Wetland
	6	Cortaillod-Est	Chaix 1986	Wetland
	17	Vinelz BE-Ländti	Stampfli unp. (IPAS)	Wetland
	57	Wasserburg D-Buchau	Kokabi 1990	Wetland
	45	Fällanden ZH-Riedspitz	Schibler unp. (IPAS)	Wetland
	13	Le Landeron NE-Les Marais	Borrello/Chaix 1983	Wetland
	43	Meilen ZH-Schellen	Schibler unp. (IPAS)	Wetland
	49	Uerschhausen TG-Horn (excl. Schicht 1)	Markert unp.	Wetland
	1	Genève GE-Eaux-Vives	Revilliod/Reverdin 1927	Wetland
	32	Hallwil AG-Rostbau	Steinmann 1923 & 1925	Wetland
	74	Ayent VS-Le Château	Chaix 1990b	Dryland
	2	Bavois VD-En Raillon	Chaix 1984	Dryland
	69	Cresta GR-Cazis, Planum 14	Plüss 2011	Dryland
	35	Loppburg NW-Stansstad	Stopp 2007	Dryland
	26	Nunningen SO-Portiflue	Schibler 1996b	Dryland
	60	Oberriet SG-Montlingerberg	Würgler 1962	Dryland
	24	Pieterlen BE-Under Siedebrunne 3	Deschler-Erb 2005	Dryland
	30	Möriken AG-Kestenberg II+III	Schmid 1952	Dryland
	66	Ramosch GR-Mottata	Würgler 1962	Dryland
	68	Savognin GR-Padnal, Horizont H-B	Bopp-Ito unp. (IPAS)	Dryland
	48	Schleitheim SH-Auf der Egg	Rehazek unp. (IPAS)	Dryland
	76	Vex VS-Le Château	Chaix 1990a	Dryland
	29	Wittnau AG-Wittnauerhorn 3b	Schibler 1996a	Dryland
Middle Bronze Age	36	Cham ZG-Oberwil	Schibler/Veszeli 2001	Dryland
	25	Cornol JU-Mont Terri	Morel 1988	Dryland
	69	Cresta GR-Cazis, Planum 10-12	Plüss 2011	Dryland
	59	Kirchberg SG-St. Iddaburg	Würgler 1956	Dryland
	70	Lumbrein-Srin GR-Crestaulta	Rüegger 1942	Dryland
	68	Savognin GR-Padnal, C	Bopp-Ito unp. (IPAS)	Dryland
	67	Scuol GR-Avant Muglins	Rehazek unp. IPAS)	Dryland
	67	Scuol GR-Munt Baselgia, I-II	Kaufmann 1983	Dryland
	67	Scuol GR-Munt Baselgia, I-III	Kaufmann 1983	Dryland
	72	Zeneggen VS-Kasteltschuggen	Chaix unp.	Dryland
Early Bronze Age	74	Ayent VS-Le Château	Chaix 1990b	Dryland
	69	Cresta GR-Cazis, Planum 1-8	Plüss 2011	Dryland
	68	Savognin GR-Padnal, D	Bopp-Ito unp. (IPAS)	Dryland
	68	Savognin GR-Padnal, E	Bopp-Ito unp. (IPAS)	Dryland
	61	Schellenberg FL-Borscht	Hartmann-Frick 1964; Kuhn 1937	Dryland
	67	Scuol GR-Motta Sfondraz	Schibler in Rageth 1998	Dryland
	75	Sion VS-Petit-Chasseur	Chaix 1976a	Dryland
	76	Vex VS-Le Château	Chaix 1990a	Dryland
	58	Arbon TG-Bleiche 2	Kuhn/Güller 1946	Wetland
	54	Bodman D-Schachen, Befund 2+4	Kokabi 1990	Wetland
	57	Bad Buchau D-Forschner	Kokabi 1990	Wetland
	33	Hochdorf LU-Baldegg	Hescheler/Rüegger 1940	Wetland
	44	Meilen ZH-Obermeilen	Kuhn 1935	Wetland
	42	Wädenswil ZH-Vorder Au S.1	Rehazek 2005	Wetland
	42	Wädenswil ZH-Vorder Au S.0	Rehazek 2005	Wetland
	3	Yverdon VD-Garage Martin	Chaix 1976b	Wetland
	40	Zürich ZH-Bauschanze	Rehazek unp. (IPAS)	Wetland
	40	Zürich ZH-Mozartstrasse, 1o	Hüster Plogmann/Schibler 1997	Wetland
	40	Zürich ZH-Mozartstrasse, 1u	Hüster Plogmann/Schibler 1997	Wetland
		Bronze Age		

BCcal		Western and central Switzerland			Eastern Switzerland			No.	Settlements	Refernces	Dating			Dating	No.	Settlement	References	Taphonomy
				40	Zürich AKAD/Pressehaus J	Hüster-Plogmann/Schibler 1997												
3700	7	Auvernier Port Va	Chaix 1985	55	Sipplingen-Osthafen, Schicht 9	Steppan 2004												
	23	Seedorf Lobsigensee I/II	Ginella unp. (IPAS)	51	Pfyn Breitenloh	Leuzinger 2007												
				37	Zug Riesch	Schäfer unp. (IPAS)												
				40	Zürich Seefeld Kan.San. 7	Hüster-Plogmann/Schibler 1997												
				40	Zürich Seefeld Kan.San. 8	Hüster-Plogmann/Schibler 1997												
				43	Feldmeilen Vorderfeld 5	Schibler/Veszeli 1998												
				44	Meilen Rohrenhaab 4/4a	Sakellaridis 1979												
	28	Egolzwil 5	Stampfli 1976a	41	Horgen Dampfschiffsteg	Sakellaridis 1979												
				43	Feldmeilen Vorderfeld 6	Schibler/Veszeli 1998												
	27	Burgäschisee Süd	Boessneck/Jéquier/Stampfli 1963	43	Feldmeilen Vorderfeld 7	Schibler/Veszeli 1998												
	27	Burgäschisee SW	Josien 1956 and Stampfli 1964	43	Feldmeilen Vorderfeld 8	Schibler/Veszeli 1998												
				43	Feldmeilen Vorderfeld 9	Schibler/Veszeli 1998												
	7	Auvernier Port Vb-c	Chaix 1985	40	Zürich Pressehaus L	Hüster-Plogmann/Schibler 1997												
				40	Zürich Seefeld Kan.San. 9	Hüster-Plogmann/Schibler 1997												
3800	15	Twann E1+2	Becker/Johansson 1981	40	Zürich Kleiner Hafner 4G	Schibler 1987a												
	23	Seedorf Lobsigensee III	Ginella unp. (IPAS)	40	Zürich Mozartstrasse 5 oben	Hüster-Plogmann/Schibler 1997												
	28	Egolzwil 4	Stampfli 1992	40	Zürich Kleiner Hafner 4F	Schibler 1987a												
	4	Yvonand III 1+2	Chaix 1976a	40	Zürich Mozartstrasse 5 unten	Hüster-Plogmann/Schibler 1997												
	10	Muntelier Fischergässli	Morel 2000	52	Steckborn Turgi	Markert 1985												
	10	Muntelier Strandweg	Reynaud Savioz 2005															
	10	Muntelier Dorf	Lopez 2003	44	Meilen Rohrenhaab 5	Sakellaridis 1979												
	23	Seedorf Lobsigensee IV A-C2	Ginella unp. (IPAS)	40	Zürich Kleiner Hafner 4E	Schibler 1987a												
	23	Seedorf Lobsigensee IV C3	Ginella unp. (IPAS)	40	Zürich Mozartstrasse 6 oben	Hüster-Plogmann/Schibler 1997												
3900				40	Zürich Mozartstrasse 6 unten	Hüster-Plogmann/Schibler 1997												
				53	Hornstaad Hörnle I AHA	Kokabi 1990												
				40	Zürich Kleiner Hafner 4D	Schibler 1987a												
4000				36	Cham-Eslen ZG	Huber/Schaeren												
4100				40	Zürich Kleiner Hafner 4C	Schibler 1987a												
				40	Zürich Kleiner Hafner 4B	Schibler 1987a												
4200				40	Zürich Kleiner Hafner 4A	Schibler 1987a												
4300	28	Egolzwil 3	Stampfli 1992	40	Zürich Kleiner Hafner 5A+B	Schibler 1987a												

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Literature			Kreuz 2012	Maier 2001	Maier 2001	Maier 2001	Maier 2001	Maier 2001	Maier 2001	Maier 2001	Maier 2001	Brombacher & Jacomet 2003	Brombacher & Jacomet 2003	Brombacher & Jacomet 2003	Hosch & Jacomet 2004	Dick 1989	Dick 1989	Dick 1989	Brombacher & Jacomet 1997	Brombacher & Jacomet 1997	Kreuz 2012	Rösch et al 2002: Vegetation sur July 6th 2001 (12-14). Original c	
Preservation (archaeological remains)			charred remains	charred remains	charred remains	charred remains	charred remains	charred remains	charred remains	charred remains	charred remains	charred remains	charred remains	subfossil remains	subfossil remains	charred remains	charred remains	charred remains	mostly subfossil remains	mostly subfossil remains	charred remains		
	ecology (partly after Rösch et al. 2002)	life form (Info Flora)	2 stocks LBK (5400-5000 cal BC)	naked wheat house 13 Hornstaad Hörnle I, AH2 (3910 cal BC)	naked wheat house 10 Hornstaad Hörnle I, AH2 (3910 cal BC)	naked wheat house 11 Hornstaad Hörnle I, AH2 (3910 cal BC)	naked wheat house 12 Hornstaad Hörnle I, AH2 (3910 cal BC)	naked wheat house 1 Hornstaad Hörnle I, AH2 (3910 cal BC)	naked wheat house 3 Hornstaad Hörnle I, AH2 (3910 cal BC)	barley house 9 Hornstaad Hörnle I, AH2 (3910 cal BC)	hulled wheat house 12 Hornstaad Hörnle I, AH2 (3910 cal BC)	7 barley stocks from Port US (3700 BC) (probably 1 big)	1 emmer stock with einkorn from Port OS (3600 BC)	1 flax stock, Port, OS (3600 BC)	Arbon Bleiche 3: results of statistical analyses (p. 130) / **ubiquities**	4 barley stocks, Zurich Mozartstrasse, Horgener K. (3100 BC)	4 naked wheat stocks, Zurich Mozartstrasse, Horgener K. (3100 BC)	4 emmer stocks, Zurich Mozartstrasse, Horgener K. (3100 BC)	lakeshore settl. mixed assemblages (roughly semiquant.), 4300-3600 BC	lakeshore settl. mixed assemblages roughly semiquant.) 3300-2500 cal BC	from LBK pits (mixed assemblages) (present=1) (without rare cf's)	Forchtenberg winter field bread wheat, burned	Forchtenberg Winter field, bread wheat, burned
Survey No. (experimental fields)				12 samples	8 samples	7 samples	14 samples	12 samples	4 samples	7 samples	7 samples											1	2
Herbaccous layer, (%) (experimental fields)																						80	90
Herbaceous layer, (cm) (experimental fields)																						120	110
																			1=rare, 2=middle ubiquity, 3= high ubiquity		1=present		
																			<10%, 10-59%, >50%				
Crops (% for experimental fields, numbers for archaeological samples)												G, E, CH	G, E, CH										
Triticum aestivum	crops	annual																				25	20
Triricum nudum 4n (durum type)	crops	annual		4088	8466	1045	2568	2317	863	1097	837	2482	542	13		93	3948	1202					
Triticum dicoccon	crops	annual	2242									85	10846	7		589	36	14024			1		+
Triticum monococcum und dicoccon	crops	annual	2449	91	253	117	177	111	12	297	2068		175	20							1		
Triticum monococcum (incl. 2-grained)	crops	annual	4866									338	2498	3		10		10			1		
Hordeum vulgare	crops	annual		105	382	93	147	230	58	2652	432	10180	2008	1		1427	1297	595			1		
Triticum spelta	crops	annual																					
Avena sativa	crops	annual																				+	
Phacelia tanecetifolia	crops	annual																					
Sinapis alba	crops	annual																					
Linum usitatissimum	crops	annual		37	9	21	19	32		10	61		60	1028							1		
Papver somniferum	crops	annual		8	125			68	2	72	5	2		8							1		
Lens culinaris	crops	annual	2																		1		
Pisum sativum	crops	annual	1404									8	60								1		
Vicia ervilia	crops	annual	25																		1		
Vicia faba	crops	annual																			1		
Anethum graveolens	crops	annual						3															
Aethusa cynapium	crop weeds	annual										1							2	2			
Agrostemma githago	crop weeds	annual																					
Ammi majus	crop weeds	annual																	1	1			
Anagallis arvensis	crop weeds	annual																	1	2			
Aphanes arvensis	crop weeds	annual																		3			
Arenaria serpyllifolia	crop weeds	annual			1					1									2	3			
Asperula arvensis	crop weeds	annual																		1	1		
Atriplex patula (and patula/hastata)	crop weeds	annual	1																2	2	1		
Atriplex/Chenopodium	crop weeds	annual																			1		
Brassica camplestris (=rapa)	crop weeds	annual		21	85	1	4	15	2	400	21	2			90				3	3			
Bromus (cf) sterilis	crop weeds	annual	85		1																1		
Bromus cf arvensis	crop weeds	annual																			1		
Bromus cf secalinus	crop weeds	annual	831																1	1	1		
Camelina cf sativa	crop weeds	annual		1						2									3	3			
Capsella bursa-pastoris (seeds+fruits)	crop weeds	annual			6			1			3								2	2	1		
Chenopodium album	crop weeds	annual	261	14	2		4	2		2									3	3	1		
Chenopodium ficifolium	crop weeds	annual																	1	2			
Chenopodium hybridum	crop weeds	annual			3														1		1		
Chenopodium murale	crop weeds	annual																	1				
Chenopodium polyspermum	crop weeds	annual		1	11		5	2		2									2	3	1		
Chenopodium spec.	crop weeds (mostly)	annual																			1		
Centaurea cf cyanus	crop weeds	annual																	1				
Cuscuta spec.	weed/ruderal	annual										2											
Descurainia sophia	crop weeds	annual		2	444		1	1		322													
Digitaria ischaemum	crop weeds	annual																		1	1		
Digitaria sanguinalis (cf genus)	crop weeds	annual																			1		
Echinochloa crus-galli	crop weeds	annual	5																		1		
Euphorbia exigua	crop weeds	annual																		1			
Galeopsis tetrahit-type	weed/ruderal	annual		8	77	13	2	28		65	17						1		2	3			
Galeopsis cf ladanum	crop weeds	annual																	1	1			
Galium aparine (incl. type and cf, spurium etc.)	weed/ruderal	annual	19				2												1	1	1	+	+
Hyoscyamus niger	ruderal	annual																			1		
Lamium amplexicaule	crop weeds	annual																		1			
Lapsana communis	weed/ruderal/woodland glades	annual	37		6	11	2	3	7	6				1			1	2	3	3	1	+	
Lathyrus hirsutus	crop weeds	annual																	1	1			
Lathyrus nissolia	crop weeds	annual																2	1				
Matricaria perforata and recutita	ruderal / disturbed places	annual																	1		1		
Medicago lupulina	ruderal/meadows	annual-2/3 years								1													
Moehringia trinervia	woodland	annual-perennial		2	6			1			1								3	3			
Papaver argemone	crop weeds	annual																		1			
Papaver rhoeas / dubium	crop weeds	annual																	1	1	1		
Picris hieracioides	ruderal	perennial/annual										1							2	2	1		
Poa annua	ruderal / disturbed places	annual	3																	2			
Polygonum aviculare	crop weeds	annual		3															3	3			
Polygonum convolvulus	crop weeds	annual	10	7	9	2	1	2	2	2	10			2	30		3	10	3	3	1		
Polygonum dumetorum	woodland glades	annual			2					3									2	2	1		
Polygonum lapathifolium	ruderal	annual	1																				
Polygonum lapathifoium/persicaria	crop weeds/ruderal	annual	5																				
Polygonum persicaria	crop weeds	annual		1			1									1			2	3	1		
Scleranthus annuus	crop weeds	annual	2																				
Setaria verticillata/viridis	crop weeds	annual																			1		
Sherardia arvensis (cf)	crop weeds	annual																			1		

Literature			Kreuz 2012	Maier 2001	Maier 2001	Maier 2001	Maier 2001	Maier 2001	Maier 2001	Maier 2001	Maier 2001	Brombacher & Jacomet 2003	Brombacher & Jacomet 2003	Brombacher & Jacomet 2003	Hosch & Jacomet 2004	Dick 1989	Dick 1989	Dick 1989	Brombacher & Jacomet 1997	Brombacher & Jacomet 1997	Kreuz 2012	Rösch et al 2002: Vegetation sur July 6th 2001 (12-14). Original c	
Preservation (archaeological remains)			charred remains	charred remains	charred remains	charred remains	charred remains	charred remains	charred remains	charred remains	charred remains	charred remains	charred remains	subfossil remains	subfossil remains	charred remains	charred remains	charred remains	mostly subfossil remains	mostly subfossil remains	charred remains		
	ecology (partly after Rösch et al. 2002)	life form (Info Flora)	2 stocks LBK (5400-5000 cal BC)	naked wheat house 13 Hornstaad Hörnle I, AH2 (3910 cal BC)	naked wheat house 10 Hornstaad Hörnle I, AH2 (3910 cal BC)	naked wheat house 11 Hornstaad Hörnle I, AH2 (3910 cal BC)	naked wheat house 12 Hornstaad Hörnle I, AH2 (3910 cal BC)	naked wheat house 1 Hornstaad Hörnle I, AH2 (3910 cal BC)	naked wheat house 3 Hornstaad Hörnle I, AH2 (3910 cal BC)	barley house 9 Hornstaad Hörnle I, AH2 (3910 cal BC)	hulled wheat house 12 Hornstaad Hörnle I, AH2 (3910 cal BC)	7 barley stocks from Port US (3700 BC) (probably 1 big)	1 emmer stock with einkorn from Port OS (3600 BC)	1 flax stock, Port, OS (3600 BC)	Arbon Bleiche 3: results of statistical analyses (p. 130) / **ubiquities**	4 barley stocks, Zurich Mozartstrasse, Horgener K. (3100 BC)	4 naked wheat stocks, Zurich Mozartstrasse, Horgener K. (3100 BC)	4 emmer stocks, Zurich Mozartstrasse, Horgener K. (3100 BC)	lakeshore settl. mixed assemblages (roughly semiquant.), 4300-3600 BC	lakeshore settl. mixed assemblages roughly semiquant.) 3300-2500 cal BC	from LBK pits (mixed assemblages) (present=1) (without rare cf's)	Forchtenberg winter field bread wheat, burned	Forchtenberg Winter field, bread wheat, burned
Survey No. (experimental fields)				12 samples	8 samples	7 samples	14 samples	12 samples	4 samples	7 samples	7 samples											1	2
Herbaccous layer, (%) (experimental fields)																						80	90
Herbaceous layer, (cm) (experimental fields)																						120	110
																			1=rare, 2=middle ubiquity, 3= high ubiquity		1=present		
																			<10%, 10-59%, >50%				
Silene cretica	crop weeds	annual												199	77				3	2			
Silene gallica	crop weeds	annual																		1			
Silene cf noctiflora	crop weeds	annual																		1			
Sinapis arvensis	crop weeds	annual																			1		
Sisymbrium spec.	different, dep. on the species	annual																			1		
Solanum nigrum	crop weeds	annual	2							1				2	19				3	2	1		
Sonchus asper	weed/rederal	annual												1	10		1	1	2	3			
Sonchus oleraceus	crop weeds	annual																		1			
Stachys cf arvensis (incl. annua/arvensis)	crop weeds	annual																	1	2	1		
Stellaria media	crop weeds	annual					2												2	3	1		+
Thlaspi arvense	crop weeds	annual																	1	1	1		
Torilis japonica	weed/ruderal/forest fringes	annual/perennial																					
Trifolium dubium (incl. campestre/dubium/arvense)	Forest fringes, meadows	annual	4																1				
Valerianella dentata	crop weeds	annual		5	14					5				1				1	3	3	1		
Valerianella locusta	crop weeds	annual																	1	2	1		
Veronica (cf) arvensis	crop weeds	annual						1															
Vicia angustifolia	crop weeds	annual									1								1				
Vicia hirsuta	crop weeds	annual	5	3	2		1	1	1	7						1		9	1	2	1		
Vicia spec.	crop weeds	annual	27																				
Vicia tetrasperma (incl. hirsuta/tetrasperma)	crop weeds	annual	7																1	1	1		
Viola tricolor	crop weeds	annual																	2	3			
Total number of taxa, annuals	**73 Taxa**		**17**	**12**	**15**	**4**	**11**	**11**	**4**	**14**	**6**	**4**	**0**	**6**	**5**	**2**	**4**	**6**	**42**	**45**	**35**	**2**	**2**
Total number of remains, annuals			**1305**	**68**	**140**	**27**	**25**	**57**	**12**	**97**	**53**	**5**	**0**	**206**		**2**	**6**	**25**					
Agrimonia eupatoria	forest edges/meadows	perennial		1															2	2			
Ajuga reptans	Forest fringes, meadows	perennial																	2	2			
Aquilegia vulgaris	woodland	perennial						1															
Arctium minus and spec.	ruderal	perennial												1	51				2	3			
Artemisia vulgaris and spec.	ruderal	perennial																	2	2			
Campanula rapunculoides	forest fringes	perennial																	2	3			
Carex hirta	ruderal	perennial						1															
Carex spec.	not assignable	perennial											12										
Cerastium fontanum	meadows	perennial													53								
Circaea lutetiana	woodland	perennial		1																			
Cirsium arvense	Wildling assiciations	perennial																	2	2		+	
Clinopodium vulgare	Wildling assiciations	perennial																	2	3			
Daucus carota	ruderal/meadows	perennial																	3	3			
Eupatorium cannabinum	clearings/wet meadows	perennial													11	1			2	2			+
Fragaria vesca (incl. spec.)	woodland	perennial	8	1																			
Hypericum perforatum	forest edges/meadows	perennial		2																			+
Lolium/Festuca	meadows	perennial																		1			
Luzula cf multiflora	meadows	perennial		1																			
Malva silvestris (incl. spec.)	ruderal	perennial									49								2	2	1		
Nepeta cataria	ruderal	perennial							1												1		
Origanum vulgare	forest edges/meadows	perennial		1															3	3			
Phleum pratense	meadows/weeds	perennial	7															1	1	1			
Pimpinella cf saxifraga	meadows	perennial																	1	1			
Potentilla reptans	ruderal/meadows	perennial																	1	3			
Prunella vulgaris	meadows/ruderal	perennial																	2	3			
Ranunculus repens	ruderal/meadows	perennial			1		1												3	3			
Rumex crispus (incl. obtusifoilus u.a.)	ruderal / disturbed places	perennial	10																1	2			
Rumex spec.	not assignable	perennial (mostly)	12															1					
Sambucus ebulus	ruderal	perennial																	2	3	1		
Silene vulgaris	meadows	perennial		2	5	2		5	1	3									1				
Stellaria graminea (incl. palustris)	meadows	perennial	12																2	3			
Thalictrum flavum	meadows	perennial										2											
Thymus spec.	meadows	perennial																	1	2			
Trifolium repens	ruderal / disturbed places	annual																					
Urtica dioica	Ruderal communities mostly on damp ± shady places	perennial																			1		
Verbascum spec.	ruderal/meadows	perennial (mostly)																			1		
Verbena officinalis	ruderal	perennial		2			1									1	1		3	3			
Total number ofl taxa, perennials	**37 Taxa**		**5**	**8**	**2**	**1**	**2**	**3**	**2**	**1**	**1**	**1**	**1**	**1**	**3**	**2**	**1**	**2**	**22**	**22**	**5**	**1**	**2**
Total number of remains, perennials			**49**	**11**	**6**	**2**	**2**	**7**	**2**	**3**	**49**	**3**	**12**	**1**		**2**	**1**	**2**					
Brassicaceae		not assignable	4									1											
Caryophyllaceae		not assignable	3																				
Chenopodiaceae (incl. Caryophyllaceae/Chenopodiaceae)		not assignable	125																				
Fabaceae		not assignable	6															3					
Galium spec.		not assignable	6															1					
Poaceae		not assignable	496									5											
Potentilla spec.		not assignable										4											
Ranunculus spec.		not assignable										1											
Total number of taxa	**56 Taxa**			**20**	**15**	**5**	**13**	**14**	**6**	**15**	**7**	**9**	**1**	**7**	**8**	**4**	**5**	**10**					

Literature			Kreuz 2012	Maier 2001	Maier 2001	Maier 2001	Maier 2001	Maier 2001	Maier 2001	Maier 2001	Maier 2001	Brombacher & Jacomet 2003	Brombacher & Jacomet 2003	Brombacher & Jacomet 2003	Hosch & Jacomet 2004	Dick 1989	Dick 1989	Dick 1989	Brombacher & Jacomet 1997	Brombacher & Jacomet 1997	Kreuz 2012	Rösch et al 2002: Vegetation su July 6th 2001 (12-14). Original c	
Preservation (archaeological remains)			charred remains	charred remains	charred remains	charred remains	charred remains	charred remains	charred remains	charred remains	charred remains	charred remains	charred remains	subfossil remains	subfossil remains	charred remains	charred remains	charred remains	mostly subfossil remains	mostly subfossil remains	charred remains		
	ecology (partly after Rösch et al. 2002)	life form (Info Flora)	2 stocks LBK (5400-5000 cal BC)	naked wheat house 13 Hornstaad Hörnle I, AH2 (3910 cal BC)	naked wheat house 10 Hornstaad Hörnle I, AH2 (3910 cal BC)	naked wheat house 11 Hornstaad Hörnle I, AH2 (3910 cal BC)	naked wheat house 12 Hornstaad Hörnle I, AH2 (3910 cal BC)	naked wheat house 1 Hornstaad Hörnle I, AH2 (3910 cal BC)	naked wheat house 3 Hornstaad Hörnle I, AH2 (3910 cal BC)	barley house 9 Hornstaad Hörnle I, AH2 (3910 cal BC)	hulled wheat house 12 Hornstaad Hörnle I, AH2 (3910 cal BC)	7 barley stocks from Port US (3700 BC) (probably 1 big)	1 emmer stock with einkorn from Port OS (3600 BC)	1 flax stock, Port, OS (3600 BC)	Arbon Bleiche 3: results of statistical analyses (p. 130) / **ubiquities**	4 barley stocks, Zurich Mozartstrasse, Horgener K. (3100 BC)	4 naked wheat stocks, Zurich Mozartstrasse, Horgener K. (3100 BC)	4 emmer stocks, Zurich Mozartstrasse, Horgener K. (3100 BC)	lakeshore settl. mixed assemblages (roughly semiquant.), 4300-3600 BC	lakeshore settl. mixed assemblages roughly semiquant.) 3300-2500 cal BC	from LBK pits (mixed assemblages) (present=1) (without rare cf's)	Forchtenberg winter field bread wheat, burned	Forchtenberg Winter field, bread wheat, burned
Survey No. (experimental fields)				12 samples	8 samples	7 samples	14 samples	12 samples	4 samples	7 samples	7 samples											1	2
Herbaccous layer, (%) (experimental fields)																						80	90
Herbaceous layer, (cm) (experimental fields)																						120	110
																			1=rare, 2=middle ubiquity, 3= high ubiquity		1=present		
																			<10%, 10-59%, >50%				
Total number of remains				**79**	**146**	**29**	**27**	**64**	**14**	**100**	**102**	**18**	**12**	**207**		**4**	**7**	**31**					
Agropyron repens	ruderal / disturbed places	annual																					
Alopecurus myosuroides	crop weeds	annual																					
Atriplex patula	crop weeds	annual																					
Conyza canadensis	ruderal / disturbed places	annual																					
Equisetum arvense	crop weeds	annual																					
Euphorbia exigua	crop weeds	annual																					
Geranium dissectum	crop weeds	annual																					
Gnaphalium uliginosum	ruderal / disturbed places	annual																					
Gypsophila muralis	ruderal / disturbed places	annual																					
Juncus bufonius	ruderal / disturbed places	annual																					
Juncus tenuis	ruderal / disturbed places	annual																					
Kickxia elatine	crop weeds	annual																					
Kickxia spuria	crop weeds	annual																					
Lactuca serriola	ruderal / disturbed places	annual																					
Lamium purpureum	crop weeds	annual																					
Mentha arvensis	crop weeds	annual																					
Myosotis arvensis	crop weeds	annual																					
Oxalis europaea	crop weeds	annual																					
Plantago major	ruderal / disturbed places	annual																					
Polygonum mite	ruderal / disturbed places	annual																				+	
Senecio vulgaris	crop weeds	annual																					
Sonchus arvensis	crop weeds	annual																					
Trifolium hybridum	ruderal / disturbed places	annual																					
Tussilago farfara	ruderal / disturbed places	annual																					
Veronica persica	crop weeds	annual																					
Total number of annuals only on the experimental field	**ecology after Rösch et al. 2002**																					**1**	
Acer pseudoplatanus	Coppice trees	perennial																					+
Agrostis tenuis	Forest fringes, meadows	perennial																					+
Anemone nemorosa	Forest herbs	perennial																				+	
Athyrium filix-femina	Forest herbs	perennial																					
Bromus hordeaceus	Forest fringes, meadows	perennial																					
Calamagrostis cf. arundinacea	Wildling assiciations	perennial																					
Carex leporina	Wildling assiciations	perennial																					
Carex pallescens	Wildling assiciations	perennial																					
Carex sylvatica	Forest herbs	perennial																				+	+
Carpinus betulus	Coppice trees	perennial																					
Cirsium palustre	Wet grassland	perennial																					+
Cirsium vulgare	Ruderal communities mostly on damp ± shady places	perennial																					
Convallaria majalis	Forest herbs	perennial																					
Crepis mollis (cf G)	Forest fringes, meadows	perennial																					
Dactylis glomerata	Forest fringes, meadows	perennial																					+
Deschampsia caespitosa	Wet grassland	perennial																					+
Dryopteris austriaca	Forest herbs	perennial																					
Epilobium angustifolium	Wildling assiciations	perennial																					+
Epilobium hirsutum	Ruderal communities mostly on damp ± shady places	perennial																					
Epilobium montanum	Ruderal communities mostly on damp ± shady places	perennial																					
Epilobium tetragonum	Ruderal communities mostly on damp ± shady places	perennial																				+	+
Fagus sylvatica	Coppice trees	perennial																					
Festuca cf. heterophylla	Forest herbs	perennial																					
Festuca pratensis	Forest fringes, meadows	perennial																					
Glechoma hederacea	Ruderal communities mostly on damp ± shady places	perennial																					
Holcus lanatus	Wet grassland	perennial																					
Hypericum hirsutum	Wildling assiciations	perennial																					
Juncus effusus	Wet grassland	perennial																					+
Lathyrus pratensis	Forest fringes, meadows	perennial																					
Luzula luzuloides	Forest herbs	perennial																					
Luzula pilosa	Forest herbs	perennial																					
Melica uniflora	Forest herbs	perennial																					+
Milium effusum	Forest herbs	perennial																					+
Oxalis acetosella	Forest herbs	perennial																					
Plantago media	Forest fringes, meadows	perennial																					
Poa trivialis	Forest fringes, meadows	perennial																					
Potentilla sterilis	Forest herbs	perennial																					
Quercus robur	Coppice trees	perennial																					
Rubus fruticosus	Shrubs	perennial																					+
Rubus idaeus	Shrubs	perennial																				+	+
Sambucus nigra	shrubs	perennial																				+	
Scrophularia nodosa	Forest herbs	perennial																					+
Senecio sylvaticus	Wildling assiciations	perennial																					+
Stellaria holostea	Forest herbs	perennial																				+	+

Literature			Kreuz 2012	Maier 2001	Maier 2001	Maier 2001	Maier 2001	Maier 2001	Maier 2001	Maier 2001	Maier 2001	Brombacher & Jacomet 2003	Brombacher & Jacomet 2003	Brombacher & Jacomet 2003	Hosch & Jacomet 2004	Dick 1989	Dick 1989	Dick 1989	Brombacher & Jacomet 1997	Brombacher & Jacomet 1997	Kreuz 2012	Rösch et al 2002: Vegetation sur July 6th 2001 (12-14). Original c	
Preservation (archaeological remains)			charred remains	charred remains	charred remains	charred remains	charred remains	charred remains	charred remains	charred remains	charred remains	charred remains	charred remains	subfossil remains	subfossil remains	charred remains	charred remains	charred remains	mostly subfossil remains	mostly subfossil remains	charred remains		
	ecology (partly after Rösch et al. 2002)	life form (Info Flora)	2 stocks LBK (5400-5000 cal BC)	naked wheat house 13 Hornstaad Hörnle I, AH2 (3910 cal BC)	naked wheat house 10 Hornstaad Hörnle I, AH2 (3910 cal BC)	naked wheat house 11 Hornstaad Hörnle I, AH2 (3910 cal BC)	naked wheat house 12 Hornstaad Hörnle I, AH2 (3910 cal BC)	naked wheat house 1 Hornstaad Hörnle I, AH2 (3910 cal BC)	naked wheat house 3 Hornstaad Hörnle I, AH2 (3910 cal BC)	barley house 9 Hornstaad Hörnle I, AH2 (3910 cal BC)	hulled wheat house 12 Hornstaad Hörnle I, AH2 (3910 cal BC)	7 barley stocks from Port US (3700 BC) (probably 1 big)	1 emmer stock with einkorn from Port OS (3600 BC)	1 flax stock, Port, OS (3600 BC)	Arbon Bleiche 3: results of statistical analyses (p. 130) / **ubiquities**	4 barley stocks, Zurich Mozartstrasse, Horgener K. (3100 BC)	4 naked wheat stocks, Zurich Mozartstrasse, Horgener K. (3100 BC)	4 emmer stocks, Zurich Mozartstrasse, Horgener K. (3100 BC)	lakeshore settl. mixed assemblages (roughly semiquant.), 4300-3600 BC	lakeshore settl. mixed assemblages roughly semiquant.) 3300-2500 cal BC	from LBK pits (mixed assemblages) (present=1) (without rare cf's)	Forchtenberg winter field bread wheat, burned	Forchtenberg Winter field, bread wheat, burned
Survey No. (experimental fields)				12 samples	8 samples	7 samples	14 samples	12 samples	4 samples	7 samples	7 samples											1	2
Herbaccous layer, (%) (experimental fields)																						80	90
Herbaceous layer, (cm) (experimental fields)																						120	110
																			1=rare, 2=middle ubiquity, 3= high ubiquity		1=present		
																			<10%, 10-59%, >50%				
Taraxacum officinale	Forest fringes, meadows	perennial																					
Trifolium pratense	Forest fringes, meadows	perennial																					
Valeriana officinalis agg.	Wet grassland	perennial																					
Vicia sepium	Ruderal communities mostly on damp ± shady places	perennial																					
Viola reichenbachiana	Forest herbs	perennial																					+
Total number of perennials on experimental fields only																						**7**	**17**
Total number of taxa	**74 Taxa**																						

Literature			veys at Forchtenberg, June 19th, 2000 (1, 3, 5, 7, 8, 9) and Forchtenberg, July 6th 2001 (2, 4, 6, 10, 11) AND Vegetation surveys of arable fields and fallow land in the three-field-system at Wackershofen, odes replaced by "+" (meaning presence)											
Preservation (archaeological remains)														
	ecology (partly after Rösch et al. 2002)	life form (Info Flora)	Forchtenberg Summer field, emmer, burned	Forchtenberg Summer field, emmer, burned	Forchtenberg Summer field, barley, burned	Forchtenberg Summer field, barley,	Forchtenberg Fallow land, beside summer field, unburned	Forchtenberg Fallow land, north of winter field, burned	Forchtenberg Fallow land, northwest of winter field, unburned	Forchtenberg Permanent cultivation, bread wheat, autumn sown	Forchtenberg Permanent cultivation, barley, spring sown	Wackershofen 3-field-system winter field	Wackershofen 3-field system. summer field	Wackershofen 3-field system fallow field
Survey No. (experimental fields)			3	4	5	6	7	8	9	10	11	12	13	14
Herbaccous layer, (%) (experimental fields)			50	35	50	35	80	95	100	90	93	70	80	95
Herbaceous layer, (cm) (experimental fields)			70	130	70	100	120	70	140	140	50	60	50	60
Crops (% for experimental fields, numbers for archaeological samples)														
Triticum aestivum	crops	annual				15				20			(+)	+
Triricum nudum 4n (durum type)	crops	annual												
Triticum dicoccon	crops	annual	15	15										
Triticum monococcum und dicoccon	crops	annual												
Triticum monococcum (incl. 2-grained)	crops	annual												
Hordeum vulgare	crops	annual			20						3			
Triticum spelta	crops	annual										20		
Avena sativa	crops	annual				+							40	
Phacelia tanecetifolia	crops	annual											+	
Sinapis alba	crops	annual											+	
Linum usitatissimum	crops	annual												
Papver somniferum	crops	annual												
Lens culinaris	crops	annual												
Pisum sativum	crops	annual												
Vicia ervilia	crops	annual												
Vicia faba	crops	annual												
Anethum graveolens	crops	annual												
Aethusa cynapium	crop weeds	annual												
Agrostemma githago	crop weeds	annual												
Ammi majus	crop weeds	annual												
Anagallis arvensis	crop weeds	annual										+	+	
Aphanes arvensis	crop weeds	annual												
Arenaria serpyllifolia	crop weeds	annual												
Asperula arvensis	crop weeds	annual												
Atriplex patula (and patula/hastata)	crop weeds	annual											+	
Atriplex/Chenopodium	crop weeds	annual												
Brassica camplestris (=rapa)	crop weeds	annual												
Bromus (cf) sterilis	crop weeds	annual												
Bromus cf arvensis	crop weeds	annual												
Bromus cf secalinus	crop weeds	annual												
Camelina cf sativa	crop weeds	annual												
Capsella bursa-pastoris (seeds+fruits)	crop weeds	annual												
Chenopodium album	crop weeds	annual											+	
Chenopodium ficifolium	crop weeds	annual												
Chenopodium hybridum	crop weeds	annual												
Chenopodium murale	crop weeds	annual												
Chenopodium polyspermum	crop weeds	annual											+	
Chenopodium spec.	crop weeds (mostly)	annual												
Centaurea cf cyanus	crop weeds	annual												
Cuscuta spec.	weed/ruderal	annual												
Descurainia sophia	crop weeds	annual												
Digitaria ischaemum	crop weeds	annual												
Digitaria sanguinalis (cf genus)	crop weeds	annual												
Echinochloa crus-galli	crop weeds	annual												
Euphorbia exigua	crop weeds	annual												
Galeopsis tetrahit-type	weed/ruderal	annual			+					+				
Galeopsis cf ladanum	crop weeds	annual												
Galium aparine (incl. type and cf, spurium etc.)	weed/ruderal	annual	+	+						+	+		(+)	
Hyoscyamus niger	ruderal	annual												
Lamium amplexicaule	crop weeds	annual												
Lapsana communis	weed/ruderal/woodland glades	annual											+	
Lathyrus hirsutus	crop weeds	annual												
Lathyrus nissolia	crop weeds	annual												
Matricaria perforata and recutita	ruderal / disturbed places	annual										+	+	+
Medicago lupulina	ruderal/meadows	annual-2/3 years												
Moehringia trinervia	woodland	annual-perennial							+					
Papaver argemone	crop weeds	annual												
Papaver rhoeas / dubium	crop weeds	annual												
Picris hieracioides	ruderal	perennial/annual												+
Poa annua	ruderal / disturbed places	annual										+		+
Polygonum aviculare	crop weeds	annual										+		
Polygonum convolvulus	crop weeds	annual											(+)	
Polygonum dumetorum	woodland glades	annual												
Polygonum lapathifolium	ruderal	annual												
Polygonum lapathifoium/persicaria	crop weeds/ruderal	annual												
Polygonum persicaria	crop weeds	annual										(+)	+	
Scleranthus annuus	crop weeds	annual												
Setaria verticillata/viridis	crop weeds	annual												
Sherardia arvensis (cf)	crop weeds	annual												

Literature			veys at Forchtenberg, June 19th, 2000 (1, 3, 5, 7, 8, 9) and Forchtenberg, July 6th 2001 (2, 4, 6, 10, 11) AND Vegetation surveys of arable fields and fallow land in the three-field-system at Wackershofen, odes replaced by "+" (meaning presence)											
Preservation (archaeological remains)														
	ecology (partly after Rösch et al. 2002)	life form (Info Flora)	Forchtenberg Summer field, emmer, burned	Forchtenberg Summer field, emmer, burned	Forchtenberg Summer field, barley, burned	Forchtenberg Summer field, barley,	Forchtenberg Fallow land, beside summer field, unburned	Forchtenberg Fallow land, north of winter field, burned	Forchtenberg Fallow land, northwest of winter field, unburned	Forchtenberg Permanent cultivation, bread wheat, autumn sown	Forchtenberg Permanent cultivation, barley, spring sown	Wackershofen 3-field-system winter field	Wackershofen 3-field system. summer field	Wackershofen 3-field system fallow field
Survey No. (experimental fields)			3	4	5	6	7	8	9	10	11	12	13	14
Herbaccous layer, (%) (experimental fields)			50	35	50	35	80	95	100	90	93	70	80	95
Herbaceous layer, (cm) (experimental fields)			70	130	70	100	120	70	140	140	50	60	50	60
Silene cretica	crop weeds	annual												
Silene gallica	crop weeds	annual												
Silene cf noctiflora	crop weeds	annual												
Sinapis arvensis	crop weeds	annual	+	+									+	
Sisymbrium spec.	different, dep. on the species	annual												
Solanum nigrum	crop weeds	annual												
Sonchus asper	weed/rederal	annual							+		+	+	+	
Sonchus oleraceus	crop weeds	annual	+											
Stachys cf arvensis (incl. annua/arvensis)	crop weeds	annual												
Stellaria media	crop weeds	annual												
Thlaspi arvense	crop weeds	annual											+	
Torilis japonica	weed/ruderal/forest fringes	annual/perennial												
Trifolium dubium (incl. campestre/dubium/arvense)	Forest fringes, meadows	annual												+
Valerianella dentata	crop weeds	annual												
Valerianella locusta	crop weeds	annual												
Veronica (cf) arvensis	crop weeds	annual										(+)		+
Vicia angustifolia	crop weeds	annual												
Vicia hirsuta	crop weeds	annual												
Vicia spec.	crop weeds	annual												
Vicia tetrasperma (incl. hirsuta/tetrasperma)	crop weeds	annual									+	+	+	+
Viola tricolor	crop weeds	annual												
Total number of taxa, annuals	**73 Taxa**		**3**	**2**	**1**	**0**	**0**	**0**	**2**	**2**	**3**	**7**	**9**	**6**
Total number of remains, annuals														
Agrimonia eupatoria	forest edges/meadows	perennial												
Ajuga reptans	Forest fringes, meadows	perennial								+				
Aquilegia vulgaris	woodland	perennial												
Arctium minus and spec.	ruderal	perennial												
Artemisia vulgaris and spec.	ruderal	perennial												
Campanula rapunculoides	forest fringes	perennial												
Carex hirta	ruderal	perennial												
Carex spec.	not assignable	perennial												
Cerastium fontanum	meadows	perennial												
Circaea lutetiana	woodland	perennial												
Cirsium arvense	Wildling assiciations	perennial		+	+					+	+	+		+
Clinopodium vulgare	Wildling assiciations	perennial												
Daucus carota	ruderal/meadows	perennial												
Eupatorium cannabinum	clearings/wet meadows	perennial	+	+	+		+	+						
Fragaria vesca (incl. spec.)	woodland	perennial								+				
Hypericum perforatum	forest edges/meadows	perennial					+							
Lolium/Festuca	meadows	perennial												
Luzula cf multiflora	meadows	perennial												
Malva silvestris (incl. spec.)	ruderal	perennial												
Nepeta cataria	ruderal	perennial												
Origanum vulgare	forest edges/meadows	perennial												
Phleum pratense	meadows/weeds	perennial										+		
Pimpinella cf saxifraga	meadows	perennial												
Potentilla reptans	ruderal/meadows	perennial												
Prunella vulgaris	meadows/ruderal	perennial												
Ranunculus repens	ruderal/meadows	perennial											+	+
Rumex crispus (incl. obtusifoilus u.a.)	ruderal / disturbed places	perennial										+	+	+
Rumex spec.	not assignable	perennial (mostly)												
Sambucus ebulus	ruderal	perennial												
Silene vulgaris	meadows	perennial												
Stellaria graminea (incl. palustris)	meadows	perennial												
Thalictrum flavum	meadows	perennial												
Thymus spec.	meadows	perennial												
Trifolium repens	ruderal / disturbed places	annual										(+)		
Urtica dioica	Ruderal communities mostly on damp ± shady places	perennial			+		+							
Verbascum spec.	ruderal/meadows	perennial (mostly)												
Verbena officinalis	ruderal	perennial												
Total number ofl taxa, perennials	**37 Taxa**		**1**	**2**	**2**	**0**	**3**	**1**	**0**	**3**	**1**	**4**	**2**	**3**
Total number of remains, perennials														
Brassicaceae		not assignable												
Caryophyllaceae		not assignable												
Chenopodiaceae (incl. Caryophyllaceae/Chenopodiaceae)		not assignable												
Fabaceae		not assignable												
Galium spec.		not assignable												
Poaceae		not assignable												
Potentilla spec.		not assignable												
Ranunculus spec.		not assignable												
Total number of taxa	**56 Taxa**													

Literature			veys at Forchtenberg, June 19th, 2000 (1, 3, 5, 7, 8, 9) and Forchtenberg, July 6th 2001 (2, 4, 6, 10, 11) AND Vegetation surveys of arable fields and fallow land in the three-field-system at Wackershofen, odes replaced by "+" (meaning presence)											
Preservation (archaeological remains)														
	ecology (partly after Rösch et al. 2002)	life form (Info Flora)	Forchtenberg Summer field, emmer, burned	Forchtenberg Summer field, emmer, burned	Forchtenberg Summer field, barley, burned	Forchtenberg Summer field, barley,	Forchtenberg Fallow land, beside summer field, unburned	Forchtenberg Fallow land, north of winter field, burned	Forchtenberg Fallow land, northwest of winter field, unburned	Forchtenberg Permanent cultivation, bread wheat, autumn sown	Forchtenberg Permanent cultivation, barley, spring sown	Wackershofen 3-field-system winter field	Wackershofen 3-field system. summer field	Wackershofen 3-field system fallow field
Survey No. (experimental fields)			3	4	5	6	7	8	9	10	11	12	13	14
Herbaccous layer, (%) (experimental fields)			50	35	50	35	80	95	100	90	93	70	80	95
Herbaceous layer, (cm) (experimental fields)			70	130	70	100	120	70	140	140	50	60	50	60
Total number of remains														
Agropyron repens	ruderal / disturbed places	annual										+	+	+
Alopecurus myosuroides	crop weeds	annual									+	+	+	+
Atriplex patula	crop weeds	annual											+	
Conyza canadensis	ruderal / disturbed places	annual												
Equisetum arvense	crop weeds	annual										+	+	+
Euphorbia exigua	crop weeds	annual											+	
Geranium dissectum	crop weeds	annual											+	+
Gnaphalium uliginosum	ruderal / disturbed places	annual										+		
Gypsophila muralis	ruderal / disturbed places	annual										+		
Juncus bufonius	ruderal / disturbed places	annual										+		
Juncus tenuis	ruderal / disturbed places	annual		+		+		+						
Kickxia elatine	crop weeds	annual										+		
Kickxia spuria	crop weeds	annual											+	
Lactuca serriola	ruderal / disturbed places	annual										(+)		
Lamium purpureum	crop weeds	annual											+	
Mentha arvensis	crop weeds	annual										+		+
Myosotis arvensis	crop weeds	annual											+	+
Oxalis europaea	crop weeds	annual												+
Plantago major	ruderal / disturbed places	annual										+	+	+
Polygonum mite	ruderal / disturbed places	annual												
Senecio vulgaris	crop weeds	annual											(+)	
Sonchus arvensis	crop weeds	annual	+										+	
Trifolium hybridum	ruderal / disturbed places	annual											+	+
Tussilago farfara	ruderal / disturbed places	annual											(+)	+
Veronica persica	crop weeds	annual											+	
Total number of annuals only on the experimental field	**ecology after Rösch et al. 2002**		**1**	**1**		**1**		**1**			**1**	**10**	**15**	**10**
Acer pseudoplatanus	Coppice trees	perennial					+							
Agrostis tenuis	Forest fringes, meadows	perennial				+								
Anemone nemorosa	Forest herbs	perennial												
Athyrium filix-femina	Forest herbs	perennial							+					
Bromus hordeaceus	Forest fringes, meadows	perennial												+
Calamagrostis cf. arundinacea	Wildling assiciations	perennial			+				+					
Carex leporina	Wildling assiciations	perennial	+		+									
Carex pallescens	Wildling assiciations	perennial					+		+					
Carex sylvatica	Forest herbs	perennial				+								
Carpinus betulus	Coppice trees	perennial												
Cirsium palustre	Wet grassland	perennial	+				+	+	+		+			
Cirsium vulgare	Ruderal communities mostly on damp ± shady places	perennial												
Convallaria majalis	Forest herbs	perennial	+	+	+									
Crepis mollis (cf G)	Forest fringes, meadows	perennial										(+)		
Dactylis glomerata	Forest fringes, meadows	perennial					+	+	+	+	+			
Deschampsia caespitosa	Wet grassland	perennial				+	+	+	+		+			
Dryopleris austriaca	Forest herbs	perennial							+					
Epilobium angustifolium	Wildling assiciations	perennial					+	+						
Epilobium hirsutum	Ruderal communities mostly on damp ± shady places	perennial							+	+				
Epilobium montanum	Ruderal communities mostly on damp ± shady places	perennial	+				+	+			+			
Epilobium tetragonum	Ruderal communities mostly on damp ± shady places	perennial		+						+	+	+		
Fagus sylvatica	Coppice trees	perennial									+			
Festuca cf. heterophylla	Forest herbs	perennial		+										
Festuca pratensis	Forest fringes, meadows	perennial	+		+									
Glechoma hederacea	Ruderal communities mostly on damp ± shady places	perennial									+			
Holcus lanatus	Wet grassland	perennial							+				(+)	
Hypericum hirsutum	Wildling assiciations	perennial		+										
Juncus effusus	Wet grassland	perennial					+		+					
Lathyrus pratensis	Forest fringes, meadows	perennial								+	+			+
Luzula luzuloides	Forest herbs	perennial			+		+							
Luzula pilosa	Forest herbs	perennial			+									
Melica uniflora	Forest herbs	perennial			+						+			
Milium effusum	Forest herbs	perennial			+									
Oxalis acetosella	Forest herbs	perennial								+				
Plantago media	Forest fringes, meadows	perennial							+					
Poa trivialis	Forest fringes, meadows	perennial			+					+	+	+	+	+
Potentilla sterilis	Forest herbs	perennial									+			
Quercus robur	Coppice trees	perennial					+							
Rubus fruticosus	Shrubs	perennial	+		+	+	+	+	+					
Rubus idaeus	Shrubs	perennial		+		+		+			+			
Sambucus nigra	shrubs	perennial												
Scrophularia nodosa	Forest herbs	perennial	1	+	+	+					+			
Senecio sylvaticus	Wildling assiciations	perennial			+									
Stellaria holostea	Forest herbs	perennial			+					+				

Literature			veys at Forchtenberg, June 19th, 2000 (1, 3, 5, 7, 8, 9) and Forchtenberg, July 6th 2001 (2, 4, 6, 10, 11) AND Vegetation surveys of arable fields and fallow land in the three-field-system at Wackershofen, odes replaced by "+" (meaning presence)											
Preservation (archaeological remains)														
	ecology (partly after Rösch et al. 2002)	life form (Info Flora)	Forchtenberg Summer field, emmer, burned	Forchtenberg Summer field, emmer, burned	Forchtenberg Summer field, barley, burned	Forchtenberg Summer field, barley,	Forchtenberg Fallow land, beside summer field, unburned	Forchtenberg Fallow land, north of winter field, burned	Forchtenberg Fallow land, northwest of winter field, unburned	Forchtenberg Permanent cultivation, bread wheat, autumn sown	Forchtenberg Permanent cultivation, barley, spring sown	Wackershofen 3-field-system winter field	Wackershofen 3-field system. summer field	Wackershofen 3-field system fallow field
Survey No. (experimental fields)			3	4	5	6	7	8	9	10	11	12	13	14
Herbaccous layer, (%) (experimental fields)			50	35	50	35	80	95	100	90	93	70	80	95
Herbaceous layer, (cm) (experimental fields)			70	130	70	100	120	70	140	140	50	60	50	60
Taraxacum officinale	Forest fringes, meadows	perennial										+	+	+
Trifolium pratense	Forest fringes, meadows	perennial											(+)	+
Valeriana officinalis agg.	Wet grassland	perennial			+		+				+			
Vicia sepium	Ruderal communities mostly on damp ± shady places	perennial											(+)	+
Viola reichenbachiana	Forest herbs	perennial								+				
Total number of perennials on experimental fields only			**7**	**6**	**14**	**6**	**12**	**7**	**12**	**8**	**14**	**4**	**5**	**6**
Total number of taxa	**74 Taxa**													