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LAND USE IN THE EASTERN ALPS DURING THE BRONZE AGE—AN ARCHAEOBOTANICAL CASE STUDY OF A HILLTOP SETTLEMENT IN THE MONTAFON (WESTERN AUSTRIA)*

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*Investigations of the oldest prehistoric settlement in the western Austrian county of the Vorarlberg reveal a deeper insight into the colonization of the Alps. The human presence is recorded from the Late Neolithic (*c*. 3000 cal.* BC*) onwards, reflecting farming and possible mining activities. Three distinct settlement phases are recognized palynologically: (1) in the Early and Middle Bronze Ages (*c*. 1700 cal.* BC*), (2) during the Iron Age (*c*. 500 cal.* BC*) and (3) at the beginning of the medieval era (*c*. cal.* AD *800). In addition plant macrofossil analyses of soil samples from the archaeological excavation of the Bronze Age settlement of Friaga indicate a complex subsistence strategy of the Middle Bronze Age settlers, whereby cereals and pulses reveal a balanced diet.*

KEYWORDS: VEGETATION HISTORY, HUMAN IMPACT, BRONZE AGE, MONTAFON, VORARLBERG, AUSTRIA, ANTHROPOGENIC ACTIVITY, COPPICING, SUBSISTENCE STRATEGY

INTRODUCTION

The vegetation and settlement history of the Vorarlberg, the westernmost county of Austria adjacent to Switzerland (Fig. 1), has not been well investigated so far. The first pollen analyses were carried out at the beginning of the last century, whereas recent ones are published only for the Rhine Valley (De Graaf *et al.* 1989) and the Montafon (Kostenzer 1996; and see Fig. 1), a major side valley of the Rhine in the south of the county. The latter investigations indicate a first human impact during the Bronze Age (*c*. 2000 cal. BC), which has been affirmed by several finds of artefacts from the mentioned Alpine area that supported the human presence in this period. These palynological results stimulated an extensive archaeological survey in the region and brought about the discovery of the first prehistoric settlement in the village of Bartholomäberg in the Montafon Valley (Krause 2001). In 1999, an interdisciplinary research project was initiated between the Freie Universität Berlin, the Institut für Prähistorische Archäologie, the University of Mining and Technology in Freiberg/Sachsen, Institute of Archaeometry, and the University of Innsbruck, Institute of Botany, to investigate the colonization of the valley, and to evaluate and reconstruct the economic and the environmental relationships of the prehistoric settlers.

The prehistoric settlement at Friaga (Fig. 2) was occupied from the Early Bronze Age until the Middle Bronze Age and then again during the Late Iron Age. The main objective of the archaeobotanical research programme is to reconstruct the vegetation and settlement

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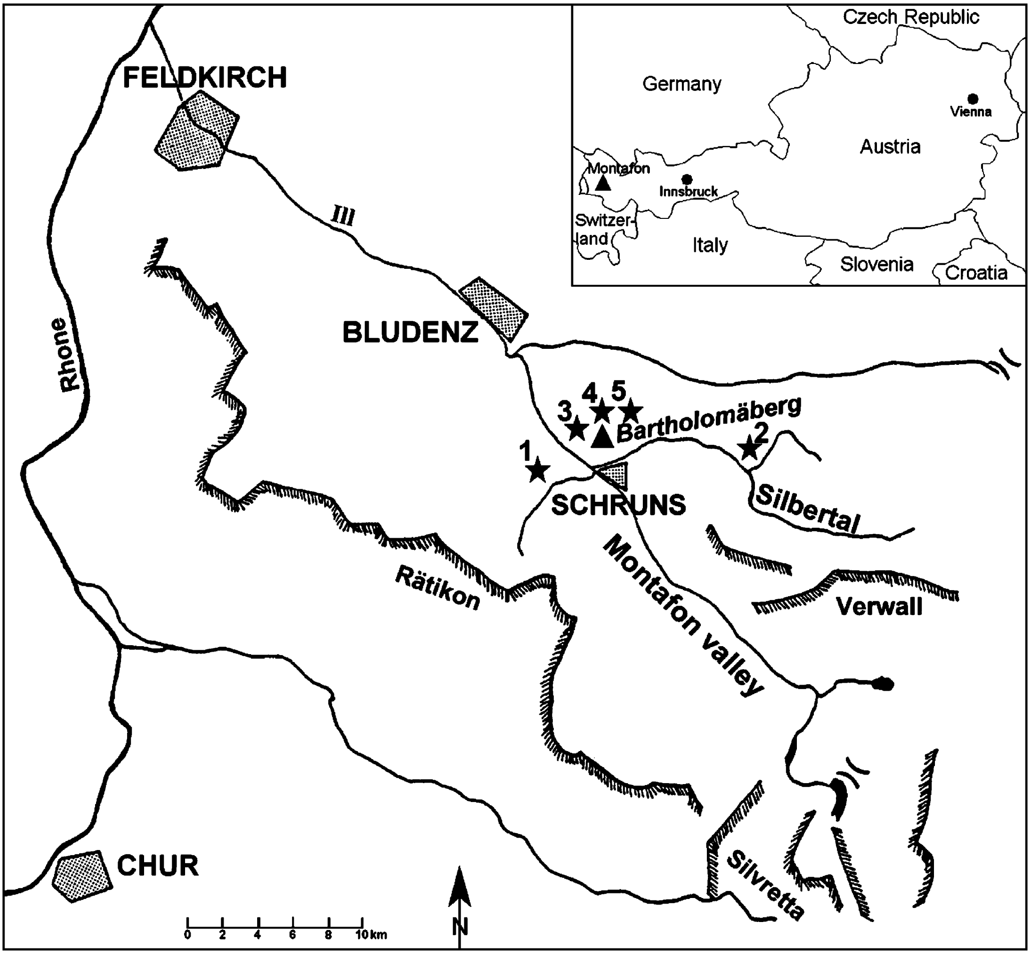

Figure 1 *The location of the Bronze Age settlement in the village of Bartholomäberg in the Montafon Valley, Vorarlberg, Austria. 1, Matschwitz (1500 m); 2, Wildes Ried (1560 m); 3, Brannertsried (1020 m); 4, Tschuga (1200 m); 5, Garsella (1460 m).*

history of the Montafon Valley as well as the subsistence strategy of the prehistoric settlers. The reconstruction is based on two data sets: the on-site and the off-site data (Kreuz 1994–5, 1995). The on-site data come from the archaeological site and provide information about the personal requirements of prehistoric settlers by analysing plant macro-remains collected during the archaeological excavation. This plant material was introduced to the site for a variety of purposes, including food for people or livestock, building materials and fuel, and also for decorative or ritual activities. The charred seeds, fruits, wood and so on reflect the rural economy and the vegetation in the surroundings of the settlement. The off-site research concerns palaeoclimatic and palynological investigations. For this purpose, the deposits of three peat bogs in the nearer and wider vicinity of the prehistoric settlement were investigated by pollen analysis (Fig. 3).

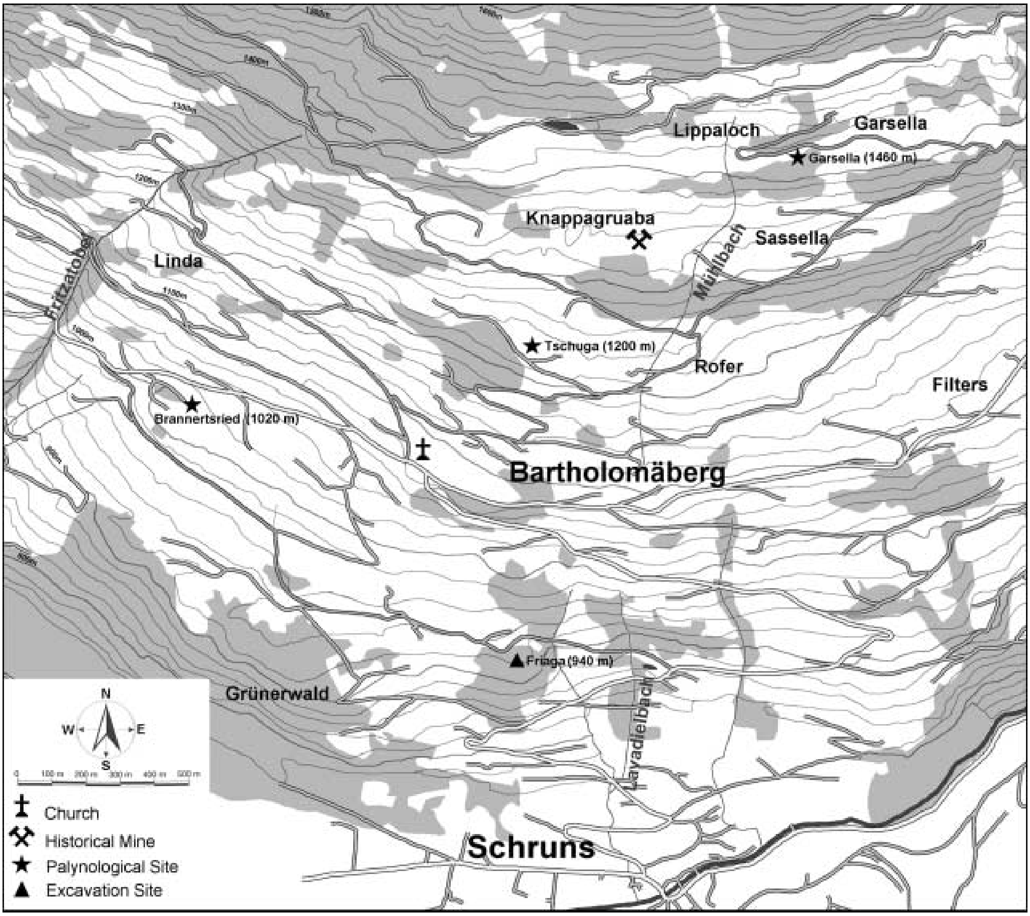

Figure 2 *A detailed map showing the Friaga excavation site and the three recently investigated palynological sites at Brannertsried, Tschuga and Garsella.*

THE INVESTIGATED AREA

The Montafon Valley is located in the southern part of the county of the Vorarlberg. It is bordered on three sides by high mountain ranges, the Verwall, the Silvretta and the Rätikon, and in the north it meets the Walgau, the lowlands of the River Ill (Fig. 1). The prehistoric settlement is placed on a hilltop called Friaga, at an altitude of 940 m on the south-facing slope of the village of Bartholomäberg. The climate of the Montafon is temperate, with an intermediate position between sub-oceanic and subcontinental. In Schruns, located below Bartholomäberg in the valley bottom at an altitude of 689 m (Fig. 2), the annual mean temperature is about 7.4°C and precipitation reaches 1243 mm, which is evenly spread throughout the year, without particularly dry periods (Walter and Lieth 1967). On the whole, the area is characterized by moderate temperatures with occasionally strong rainfall. The slopes in Bartholomäberg belong to the northern edge of the crystalline zone, which consists mainly of phyllite gneiss and mica slate. The present vegetation is dominated by subcontinental, inter-alpine montane spruce–fir forest (Piceo–Abietetum; see Mayer 1974). In the valley bottoms at an altitude of about 700 m, there are grasslands as well as remnants of deciduous forests composed of beech (*Fagus*), ash (*Fraxinus*), maple (*Acer*), lime (*Tilia*) and alder (*Alnus*).

MATERIALS AND METHODS

Pollen analyses

The selection of peat deposits for the palynological investigations was made after an extensive survey of the mires in the area. Three mires were chosen for the investigations according to their distance from the prehistoric settlement and their altitudinal position (Fig. 2). The closest investigated mire is Tschuga, located at 1200 m to the north of the prehistoric settlement. To the west of the excavation site, the second mire, Brannertsried, is situated at an altitude of 1020 m. The Garsella mire is located at the highest altitude (1460 m) of the investigated sites. After a precise stratigraphical investigation, the peat deposits were sampled using a Geonor piston corer. The subsampling of the peat cores, the chemical treatment of the peat samples and the preparation of stained microscopic slides followed standardized methods used at the Botanical Institute, Innsbruck (Seiwald 1980). At ×400 magnification, the pollen were counted using a light-transmitting microscope (Olympus BX 50) and the pollen sum counted was restricted to 1000 arboreal pollen. In this paper, the pollen diagram of Tschuga is presented, because it reflects the continuous vegetation development from the Neolithic to modern times. ^{14}C AMS dates were used for the chronological classification of the peat core. The dating (see Table 1) was carried out at the VERA laboratory at the Institute for Isotope Research and Nuclear Physics of the University of Vienna, and the calibration to calendar years was performed using Bronk Ramsey (1994).

Botanical plant macro-remains analysis

The charred plant macro-remains were taken by a random sampling strategy from the sandy loamy soil of all three occupation layers in the prehistoric dwelling place by using a mixture

Table 1 *Radiocarbon dates from peat samples from the mire at Tschuga*

Laboratory code	*Depth (cm)*	*Radiocarbon age (years BP)*	*Calibrated age range (2σ)*	*Calendar age (BC/AD)*
Vera 2826	75	1935 ± 45	50 cal. BC–AD cal. 180	AD 72
Vera 2825	85	2100 ± 30	200–40 cal. BC	142 BC
Vera 2720	100	2535 ± 30	720–540 cal. BC	765 BC
Vera 2721	140	3070 ± 30	1410–1250 cal. BC	1338 BC
Vera 2824	155	3285 ± 45	1690–1440 cal. BC	1595 BC
Vera 2823	180	3415 ± 35	1780–1610 cal. BC	1714 BC
Vera 2654	195	3510 ± 35	1930–1730 cal. BC	1827 BC
Vera 2822	217.5	3720 ± 40	2210–2010 cal. BC	2076 BC
Vera 2821	250	3900 ± 35	2470–2280 cal. BC	2422 BC
Vera 2722	275	4015 ± 30	2580–2460 cal. BC	2524 BC
Vera 2723	330	4380 ± 30	3100–2910 cal. BC	2956 BC

of bulk and point sampling techniques. In addition to that, a complementary strategy was also used, in which a precise sampling was chosen on the basis of subjective criteria such as well-stratified features, the occurrence of rich, ashy deposits, or the apparent gaps left by the random sampling strategy. The archaeological site recovered the foundations of six to eight houses, which are placed along the fortification wall in a row. Nine samples were collected within two different houses, and in the same trench of the settlement three samples were taken from cultural layers outside the houses. If possible, the targeted sample size was about 10 l. The plant material was recovered by using a water screening technique in the field. At first, the sediment was soaked thoroughly and lumps of soil were carefully broken up. Then the material was rinsed and the residues were collected in sieves of 2.0, 1.0, 0.5 and 0.25 mm mesh size. After sieving, the residue of the four fractions was dried carefully in the open air and searched for small bones, ceramic and charred material. The selection of charred seeds, fruits, grains, chaff fragments and wood for further identification was conducted in the laboratory using a stereomicroscope. The modern seed and fruit reference collection of the Botanical Institute, Innsbruck, was consulted for comparative purposes, as were specialized determination keys (Bertsch 1941; Brouwer and Stählin 1975; Beijerinck 1947; Jacomet 1987; Jacomet *et al.* 1989; Anderberg 1994).

RESULTS AND DISCUSSION

The vegetation and the land-use history

In this context, the vegetation and settlement history of the Montafon is described by the pollen profile of the mire at Tschuga (Fig. 2). In contrast to the two pollen diagrams of Brannertsried and Garsella, the diagram of the mire at Tschuga shows the human impact from the Neolithic onwards (Fig. 3) and reveals all three distinct colonization phases (the Early to Middle Bronze Age, Iron Age and medieval eras). A detailed vegetation development of the valley, based on these three palynological sites and in addition the two mires at Matschwitz and Wildes Ried, which are located at different altitudes (Fig. 1), is given in Oeggl *et al.* (2005) and Oeggl and Wahlmüller (2005).

During the Neolithic, the vegetation (Fig. 3) at the valley bottom (700 m) consists of deciduous forests of alder (*Alnus*), oak (*Quercus*), lime (*Tilia*), elm (*Ulmus*), ash (*Fraxinus excelsior*), maple (*Acer*) and hazel (*Corylus avellana*). These trees and shrubs reach altitudes up to 1000 m and then are displaced by spruce–fir forests (Piceo–Abietetum) with an admixture of beech (*Fagus*). With increasing altitude, first the occurrence of beech (*Fagus*) and then the fir (*Abies*) decreases. Above an altitude of 1700 m, pure spruce forests (Piceetum) dominate the vegetation.

The first human interference is recorded during the Copper Age, at around 3000 BC. The first clearances were cut in the deciduous forests of the valley bottoms and indicate the location of settlements in the surroundings. Beech (*Fagus*), oak (*Quercus*), ash (*Fraxinus excelsior*), alder (*Alnus*) and hazel (*Corylus avellana*) are primarily affected. Additionally, the occurrence of birch (*Betula*), hornbeam (*Carpinus betulus*), pine (*Pinus*) and larch (*Larix*) shows an opening up of the forests by their use for timber, firewood and cropland. Human activity is indicated by the first occurrence of ribwort plantain (*Plantago lanceolata* type) and juniper (*Juniperus communis*).

Starting from this primary settlement in the valley bottoms, the anthropogenic influence expands into higher altitudes and becomes detectable near the mire at Tschuga at the transition

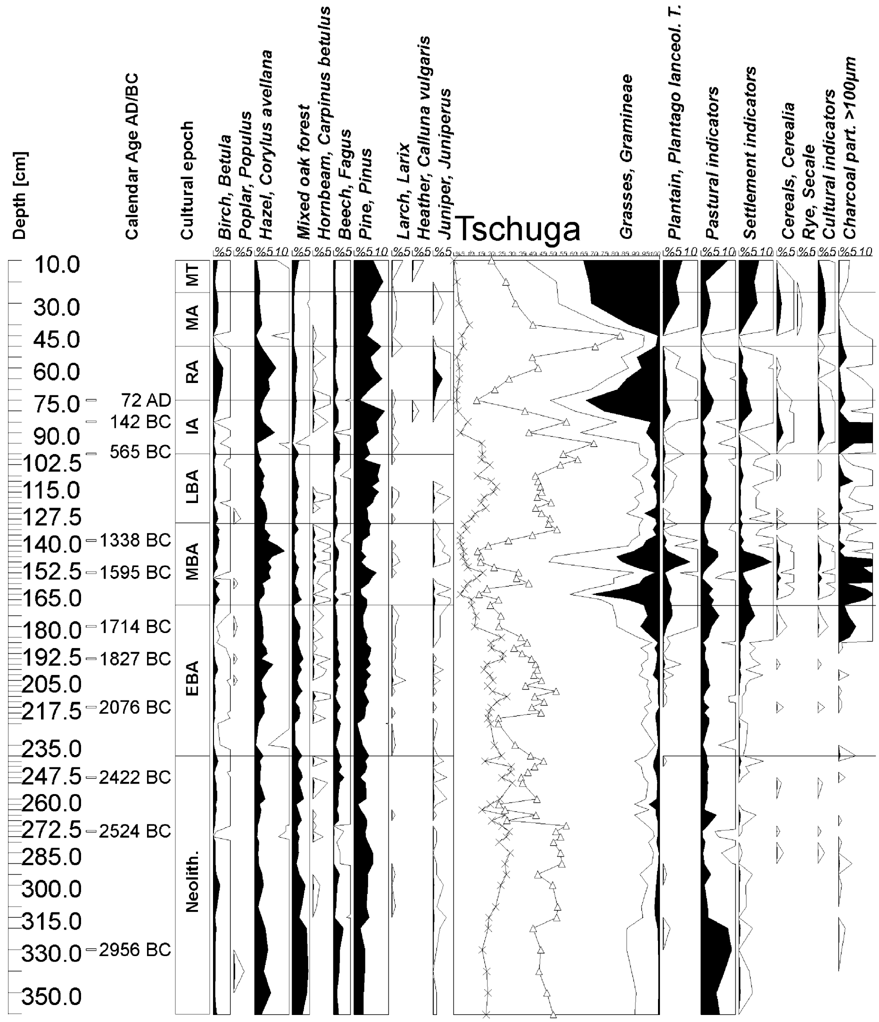

Figure 3 *A simplified pollen percentage diagram (major pollen taxa are shown) of the mire at Tschuga, located in the vicinity of the prehistoric settlement of 'Friaga'. The abbreviations in the 'Cultural epoch' column are as follows: Neolith. = Neolithic, EBA = Early Bronze Age, MBA = Middle Bronze Age, LBA = Late Bronze Age, IA = Iron Age, RA = Roman age, MA = Middle Ages, MT = modern times. The symbols in the main diagram are as follows:* × *= fir (*Abies*),* Δ *= spruce (*Picea*). Radiocarbon dates and calibrated ages are given in Table 1.*

from the Neolithic to the Early Bronze Age. In about 2500 BC, a settlement was established in the vicinity of the mire, visible in the diagram by a decline of the climax trees beech (*Fagus*), oak (*Quercus*) and spruce (*Picea*), with a contemporary occurrence of ribwort plantain (*Plantago lanceolata* type) and cereal (Cerealia) pollen (Fig. 3). The settlers operated on a small scale of about 100 years, but the utilization of the woods for pasture is traceable up to an altitude of 1600 m and even 7 km away from the settlement, in the diagrams of the mires at Wildes Ried and Garsella (Kostenzer 1996; Oeggl *et al.* 2005).

The real colonization of the valley starts in the Early Bronze Age. According to the pollen signal in the five diagrams from the Montafon, the settlement activities are concentrated in the north of the valley near Bartholomäberg, where ore deposits are located. Whether this colonization pattern close to the ore deposits is connected with early local prehistoric mining could be deduced eventually by the different land-use practises. However, it is difficult to separate the palynological signals of agricultural and metallurgic activity (Thorndycraft *et al.* 2003; Oeggl *et al.* 2005). At the very least, an indirect indication could be given by the enormous need for timber and fuel for ore winning, which was described in the 16th century by the famous mining engineer Gregorius Agricola in a manual for mining (Agricola 1556). In opposition to this are the results of palynological investigations in metal age and medieval ore mining areas, which document only a moderate opening up of the woodland (Wahlmüller 1992; Dörfler 2000; Drescher-Schneider 2003; Marshall 2003).

Nonetheless, likely ore-winning activity in the Montafon area cannot be managed without supplies from local farmers. In any case, anthropogenic activities, such as agricultural utilization, as well as the exploitation of the forests for timber and fuel for use in metallurgy, result in a clearing of the woodland. However, it can be assumed that local ore processing will cause a more intensive impact on the woodland than agriculture alone, but the demand for timber can be covered without extensive woodland devastation by effective forest management, since wood is a regenerating raw material (Gale 2003). It is a well-known fact that during historical times the enormous supply that was required was sustained by coppicing deciduous trees. At the very least, periodical coppicing favoured species with a high regenerative capacity and led to a change in the species composition of the woodland (Pott 1990; Pott and Speier 1993).

Coppicing practices are known since the Neolithic (Billamboz 1988, 2001; Willerding 1988; Rösch 1989) and the palynological results indicate that this form of sustainable forest management was also practiced in the Montafon. All of the deciduous trees—beech (*Fagus*), oak (*Quercus*), hornbeam (*Carpinus betulus*), alder (*Alnus*) and ash (*Fraxinus excelsior*)—felled during the first human occupation of the Montafon possess the property of a good response to coppicing. As a result of these clearing activities, additional light-demanding wood species, such as birch (*Betula*), hazel (*Corylus avellana*) and aspen (*Populus*), are regularly associated in coppiced woodland. Nevertheless, since the deciduous forests are restricted to small areas of the valley bottom, an enhanced timber demand has to be covered by the predominant coniferous forests. Indeed, the main human impact affects the spruce–fir forests (Piceo–Abietetum) in the immediate vicinity of the ore deposits during the Middle Bronze Age, the Iron Age and the medieval era. The palynological record (Fig. 3) documents an immense demand on the cultural landscape for timber by the sudden decrease of the spruce (*Picea*) and fir (*Abies*) values, linked to an increase in grasses (Gramineae), and in anthropogenic and cultural indicators such as cereals (Cerealia). It is surprising that the clearances during the Middle Bronze Age, which match recent dimensions, took place within a short time span. The non-arboreal pollen (NAP) spectra of the Middle Bronze Age are comparable to those of modern times. According to this, it can be assumed that the clearances reached approximately similar dimensions. Today, a grassland area of more than 3 km^2 surrounds the mire at Tschuga and we expect comparable dimensions during the Middle Bronze Age, when clearance took place within 50–100 years. The clearance phase is substituted by a phase of woodland regeneration for a period of 100 years. Extensive agricultural utilization of the area can be deduced from the high percentage of cereal (Cerealia) pollen, which occurs during the occupation phases. The fact that the anthropogenic and cultural indicators do not decrease during the woodland regeneration implies that the agrarian impact continues, although on a smaller scale than before. Hence it follows, on the one hand, that such extensive clearances are not essential for the subsistence of the farming community. On the other hand, the bipartite Middle Bronze Age clearances in particular give an idea of forest management. The first clearance is followed by a spread of pioneer woods: birch (*Betula*), hazel (*Corylus avellana*), pine (*Pinus*) and juniper (*Juniperus*), and then spruce (*Picea*) and fir (*Abies*). According to the present chronology of the events, this forest succession takes about 50 years. Then woodcutting occurs continuously for 100 years. The felled trees are now not only spruce (*Picea*) and fir (*Abies*), but also the pioneer species pine (*Pinus*) within the spruce–fir forest, which suggests that the coniferous forest has already been thinned out in previous times. In this connection, an extensive cyclic utilization of the high forest is possible. Such a sustainable utilization of the woodland requires just as many hectares as the rotation cycle makes up. According to anthracological analysis from Lincolnshire (UK), a rotation cycle for coppiced woodland from 35 to 60 years was determined (Cowgill 2003), which requires an areal dimension of 60 ha. In the case of coniferous trees, which cannot be coppiced, the high forests can only be felled extensively step by step, in such a way that the forest can regenerate itself. A circle with a radius of 1 km already produces an area of 314 ha, which corresponds to the recent cleared areas in Bartholomäberg. According to estimated wood requirements for metal production (Dörfler and Wiethold 2000), such an area of woodland yields sufficient timber for more than 100 years.

However, the sustained utilization of the woodlands in the Montafon by prehistoric settlers over thousands of years leads to a change in the species composition of the coniferous forests. Successively during the woodland regeneration phases after the Bronze and Iron Age colonization, fir (*Abies*) is unable to achieve its former position in the coniferous forests. On the one hand, the altitudinal distribution limit is reduced step by step. After the Middle Bronze Age human interference, fir (*Abies*) becomes just subdominant in the spruce–fir forests at 1200 m (Fig. 3) whereas it is still the dominant tree at 1000 m (Oeggl *et al.* 2005; Oeggl and Wahlmüller 2005). At the beginning of the Iron Age, fir (*Abies*) is almost completely absent from the coniferous woodland at 1200 m, and after the Iron Age it thrives only in the forests below 1000 m. This displacement of fir (*Abies*) seems to be caused mainly by timber exploitation. On the other hand, fir (*Abies*) as a shade-tolerant tree responds sensitively to clearing and pasturing, so that reduced propagation in the regenerating forests is plausible. Nevertheless, a possible climatic influence on this displacement of the fir (*Abies*) has to be verified using independent climate proxy data.

The husbandry regime of the Bronze Age settlers

Cultivated and gathered plants Up to now, 12 samples have been analysed from the well-stratified Middle Bronze Age layer of the 'Friaga' settlement, and the plant remains reveal a highly diversified agriculture based on a great number of different crops (Table 2). The archaeobotanical data are not associated with archaeological features. Therefore, the samples from the houses and from the cultural layer outside the buildings show no significance in their plant composition. The major part constitutes cereal remains, with grains of hulled barley (*Hordeum vulgare*; Fig. 4, 1a and 1b) predominating. Besides the barley grains, spikelet forks, glume bases and rachis internodes from emmer (*Triticum dicoccum*) and spelt (*Triticum spelta*) occur in the samples very regularly. Broomcorn millet (*Panicum miliaceum*; Fig. 4, 2a and 2b) was noticed in two samples (Table 2). Naked wheat (*Triticum aestivum*) was presented as a single grain in one sample (Table 2) and seems to be less important in the Middle Bronze Age at Friaga.

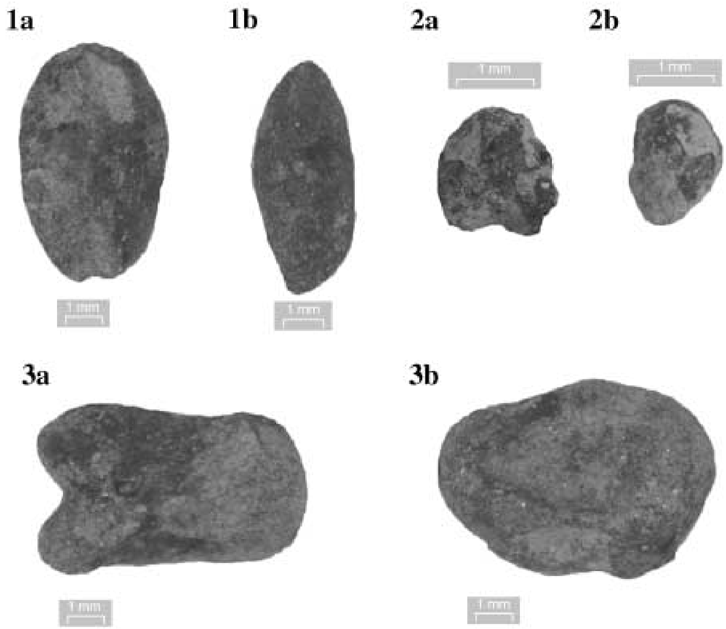

Figure 4 *Carbonized seeds and fruits of cultivated plants. 1a,b, hulled barley* (Hordeum vulgare); *2a,b, broomcorn millet* (Panicum miliaceum); *3a,b, broad bean* (Vicia faba).

Because barley contains less gluten than wheat, it is less suitable for bread production. Therefore, barley is consumed by humans mainly in the form of porridge (Körber-Grohne 1987). It is used rarely for bread or as an animal fodder. Barley grows best in moderate climates on fertile and well-drained soils, but it is also well adapted to the harsher conditions of drought, salinity and poor soils (Zohary and Hopf 2000). In the eastern Alps, barley is cultivated up to more than 1800 m (Zoller 1983). Because of these qualities, it was the principal grain at numerous sites of the inner Alpine area during the Bronze Age. Emmer (*Triticum dicoccum*) and spelt (*Triticum spelta*) have high gluten values. Their flour is used for baking bread. But these hulled wheat species require good soil conditions, such as humus-rich loamy soil, to produce higher yields. Millet stands up well to intense heat, poor soils and severe droughts, and its life cycle is rather short. Due to its sensitivity to frost, millet is cultivated as a summer crop. As a kind of porridge, millet is well suited for human consumption. The minor presence of einkorn (*Triticum monococcum*) and oat (*Avena* sp.) is interpreted as an admixture to the main crop.

In addition to cereals, pulses such as broad bean (*Vicia faba*; Fig. 4, 3a and 3b) and pea (*Pisum sativum*) are present in the samples (Table 2). Both species are used for the preparation of porridge or are consumed as green vegetables. Pulses have been an important source of protein from prehistoric times until the present day. In the Alpine area, broad bean and pea are cultivated as summer crop up to 1900 m, and in climatically favourable regions even up to 2150 m (Hegi n.d.). By rotation or mixing legume crops with cereals, the cultivator is able to maintain higher levels of soil fertility. Another virtue is that the seed of pulses are exceptionally rich in storage proteins, whereas grain is rich in starch. Thus they complement each other as food elements and contribute to a balanced human diet.

Table 2 *Preliminary results of the botanical macro-remains investigations from the Middle Bronze Age occupation layer in the Friaga settlement*

Taxon	*Preservation type*	*n*	*%*
Cereals			
Grains			
Hordeum vulgare (hulled barley)	Grain	36	75.0
Triticum aestivum (bread wheat)	Grain	1	8.3
Triticum dicoccum (emmer)	Grain	8	25.0
Triticum cf. *dicoccum* (emmer)	Grain	1	8.3
Triticum spelta (spelt)	Grain	2	8.3
Triticum sp. (wheat)	Grain	2	16.7
Panicum miliaceum (broomcorn millet)	Grain	3	16.7
Cerealia indet.	Grain	26	66.7
Chaff			
Hordeum vulgare (hulled barley)	Rachis internode	8	25.0
Hordeum vulgare (hulled barley)	Glume	1	8.3
Triticum dicoccum (emmer)	Spikelet fork	14	50.0
Triticum dicoccum (emmer)	Glume base	26	83.3
Triticum cf. *dicoccum* (emmer)	Spikelet fork	7	25.0
Triticum monococcum (einkorn)	Glume base	1	8.3
Triticum monococcum (einkorn)	Rachis internode	1	8.3
Triticum spelta (spelt)	Spikelet fork	2	16.7
Triticum spelta (spelt)	Glume base	3	25.0
Triticum dicoccum/monococcum (einkorn/emmer)	Spikelet fork	3	8.3
Triticum dicoccum/monococcum (einkorn/emmer)	Glume base	10	16.7
Triticum dicoccum/spelta (emmer/spelt)	Spikelet fork	1	8.3
Triticum sp. (wheat)	Spikelet fork	3	16.7
Triticum sp. (wheat)	Glume base	6	25.0
Triticum sp. (wheat)	Rachis internode	1	8.3
Pulses			
Pisum sativum (pea)	Seed	1	8.3
Vicia faba (faba bean)	Seed	7	25.0
Gathered plants			
Corylus avellana (hazelnut)	Fruit stone fragment	38	41.7
Prunus spinosa (sloe)	Fruit stone fragment	22	25.0
Rosa sp. (rose)	Fruit stone fragment	3	25.0
Rubus fruticosus (blackberry)	Fruit stone fragment	2	8.3
Rubus idaeus (raspberry)	Fruit stone fragment	22	75.0
Rubus cf. *idaeus* (raspberry)	Fruit stone fragment	1	8.3
Rubus sp. (raspberry/blackberry)	Fruit stone fragment	12	80.0
Sambucus nigra (black elderberry)	Fruit stone fragment	2	8.3
Sambucus racemosa (red elderberry)	Fruit stone fragment	30	75.0
Sambucus cf. *racemosa* (red elderberry)	Fruit stone fragment	2	16.7
Sambucus sp. (elderberry)	Fruit stone fragment	26	75.0
Weeds			
Avena fatua (wild oat)	Floret base	1	8.3
Avena sp. (oat)	Grain	1	8.3
Avena sp. (oat)	Awn fragment	88	50.0
Bromus secalinus (bromegrass)	Grain	1	8.3
Bromus sp. (brome)	Grain	1	8.3
Chenopodium album (fat hen)	Fruit	1	8.3

Table 2 *Continued*

Taxon	*Preservation type*	*n*	%
Fallopia convolvulus (black blindweed)	Fruit	8	41.7
Galium aparine (goosegrass)	Fruit	2	16.7
Malva neglecta (common mallow)	Fruit	2	8.3
Plantago major (great plantain)	Seed	3	8.3
Polygonum lapathifolium (pale persicaria)	Fruit	3	16.7
Polygonum persicaria (red shank)	Fruit	2	16.7
Polygonum lapathifolium/persicaria (persicaria)	Fruit	1	8.3
Rumex acetosella (sheep's sorrel)	Fruit	1	8.3

n = absolute number of charred remains in 12 samples in a volume of about 120 l; % = frequency of total samples in which a taxon is present; cf. = 'compares with' and denotes that a specimen most closely resembles those particular taxa more than any other.

In addition to the cultivated plants, there is evidence of gathered plants, which are continuously represented in the samples and could have been an essential part of the daily diet during the Bronze Age (Table 2). Most gathered fruit species grow in forest border scrubs (Prunetalia). The occurrence of several species in various samples suggests that at least some of the fruits were collected reasonably close to the settlement. The forest border edge or hedge communities are suggested by the presence of seeds such as hazelnut (*Corylus avellana*), sloe (*Prunus spinosa*), blackberry (*Rubus fruticosus*), raspberry (*Rubus idaeus*), black elderberry (*Sambucus nigra*), red elderberry (*Sambucus racemosa*) and rose (*Rosa* sp.).

Crop weeds The crop weeds are represented surprisingly frequently in the Middle Bronze Age layer (Table 2) and that is most probably due to on-site crop cleaning processes. Ecological indicator values of the weeds give more information about the arable fields. Most of the species are annual and prefer soils that are rich in available nitrogen and have an intermediate dampness—they are absent from both wet ground and places that may dry out. Weeds can also give more information about land-use strategies. Two groups among crop weeds are represented, Secalietea (winter annuals), and Chenopodietea (summer annuals) and ruderal plants growing on acid soil enriched in nitrogen by human activities and the proximity of settlements. Both winter and summer annuals were present among the hulled wheat and barley; therefore, it is impossible to deduce the sowing season for both crops. Three seeds of broomcorn millet (*Panicum miliaceum*) were discovered, but that is obviously an insufficient number to affirm that summer annuals were associated with this exclusively summer crop.

The crops in the Alpine area during the Bronze Age: subsistence strategies

The fact that this is the first detailed archaeobotanical investigation of a Bronze Age settlement north of the main Alpine ridge in the eastern Alps promised new insights into the subsistence strategy of prehistoric settlers in the Alps. In comparison with the results of other studies from Austria, Switzerland and Italy, a great variety of cultivated plants with cereals and pulses are represented in that region (Fig. 5 and Table 3).

In general, the cultivation of hulled barley (*Hordeum vulgare*) was very important in the Alps, predominantly in the adjacent Graubünden, a county of Switzerland, and the reason may

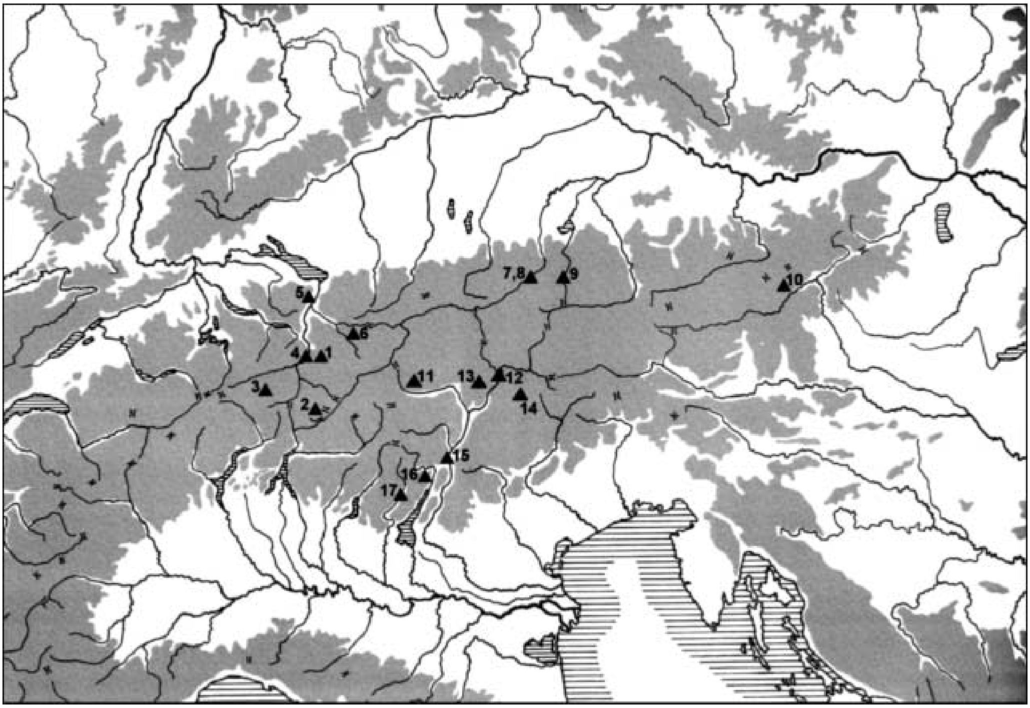

Figure 5 *A map of the investigated area, showing the 17 Bronze Age sites in the Alpine region; the numbers of the sites correspond to Table 3.*

Table 3 *Bronze Age reference sites in the Alpine area*

	Location	*Altitude (m)*	*Epoch*	*Reference*
1	Tummihügel/Maladers, CH	927	EBA	Jacomet *et al.* (1999)
2	Padnal/Savognin, CH	1210	EBA–LBA	Jacomet *et al.* (1999)
3	Crestaulta/Lumbrein-Surin, CH	1400	MBA	Jacomet *et al.* (1999)
4	Karlihof/Chur, CH	595	LBA	Jacomet *et al.* (1999)
5	Neuburg-Horst/Koblach, A	490	LBA	Werneck (1961)
6	Friaga/Bartholomäberg, A	940	MBA	
7	Mauken/Brixlegg, A	900–1000	LBA	Heiss (2001)
8	Mariahilfbergl/Brixlegg, A	900	EBA	Oeggl (unpubl. data)
9	Kelchalpe/Kitzbühel, A	1432	BA	Werneck (1949)
10	Kulm/Trofaiach, A	886	LBA	Stika (2000)
11	Ganglegg/Schluderns, I	1142	LBA	Schmidl (2002)
12	Elvas Strada/Brixen, I	566	LBA	Oeggl (unpubl. data)
13	Seeberg /Sarntal, I	2100	BA	Oeggl (1992)
14	Sotciastel/Gadertal, I	1404	MBA–LBA	Swidrak and Oeggl (1998)
15	Riparo Gaban/Trient, I	270	EBA	Nisbet (1984)
16	Fiavé/Trient, I	648	LBA	Jones and Rowley-Conwy (1984)
17	Molina di Ledro/Trient, I	660	BA	Dalla Fior (1969)

CH = Switzerland, A = Austria, I = Italy, EBA = Early Bronze Age, MBA = Middle Bronze Age, LBA = Late Bronze Age, BA = Bronze Age.

well have been the wide ecological amplitude of this crop (Table 4). Glume wheat as emmer (*Triticum dicoccum*) and spelt (*Triticum spelta*) occur steadily in the whole Alpine area, whereas in northern Italy emmer is more commonly represented (Table 4). The introduction of spelt (*Triticum spelta*) in this area is generally placed in the Early Bronze Age (Jacomet *et al.* 1999). Recent archaeobotanical data in Switzerland suggest that spelt also occurred during the Late Neolithic period (Akeret 2005). Therefore, further investigations of Neolithic sites will provide more information on the introduction of spelt in the Alpine region. Records of broomcorn millet (*Panicum miliaceum*) in Austria and northern Italy are more frequent than in the

Table 4 *The distribution of cultivated plants in the Alpine Area during the Bronze Age, subdivided by chronology and regions*

Number	*Location*	*Epoch*	Hordeum vulgare *(hulled barley)*	Hordeum vulgare *var.* nudum *(naked barley)*	Triticum aestivum/compactum/turgidum *(wheat)*	Triticum dicoccum *(emmer)*	Triticum monococcum *(einkorn)*	Triticum spelta *(spelt)*	Avena *sp. (oat)*	Panicum miliaceum *(broomcorn millet)*	Setaria italica *(foxtail millet)*	Lens culinaris *(lentil)*	Pisum sativum *(pea)*	Vicia faba *(faba bean)*
1	Tummihügel/Maladers, CH	EBA	•			•	•	•	•					
2	Padnal/Savognin, CH	EBA	•			•		•	•				•	•
3	Crestaulta/Lumbrein-Surin, CH	MBA	•		•									•
2	Padnal/Savognin, CH	MBA	•			•			•			•	•	
4	Karlihof/Chur, CH	LBA	•				•			•			•	
2	Padnal/Savognin, CH	LBA	•					•					•	
8	Mariahilfbergl/Brixlegg, A	EBA	•	•		•	•							•
6	Friaga/Bartholomäberg, A	MBA	•		•	•*	•*	•*	•	•			•	•
5	Neuburg-Horst/Koblach, A	LBA			•					•			•	•
7	Mauken/Brixlegg, A	LBA	•							•				
10	Kulm/Trofaiach, A	LBA		•	•	•*	•	•*		•		•	•	•
9	Kelchalpe/Kitzbühel, A	BA							•					
15	Riparo Gaban/Trient, I	EBA		•	•	•	•							
14	Sotciastel/Gadertal, I	M-LBA	•	•	•	•*		•*		•	•	•	•	
11	Ganglegg/Schluderns, I	LBA	•	•		•*	•	•*	•	•		•	•	•
12	Elvas Strada/Brixen, I	LBA				•*				•	•	•		
16	Fiavé/Trient, I	LBA	•		•		•	•*		•			•	
13	Seeberg /Sarntal, I	BA								•				
17	Molina di Ledro/Trient, I	BA	•			•	•			•				

CH = Switzerland, A = Austria, I = Italy, EBA = Early Bronze Age, MBA = Middle Bronze Age, LBA = Late Bronze Age, BA = Bronze Age, * = presence of spikelet forks and/or glume bases.

eastern Swiss Alps (Table 4). This distribution pattern seems to have been a methodical reason: in Switzerland the absence of broomcorn millet, and also of other species that produce small seeds, is caused by the use of sieves with a large mesh size. High quantities of broomcorn millet are recorded in the Late Bronze Age storage house of Ganglegg/Schluderns in the Vinschgau (Schmidl 2002). Therefore, the warmth-demanding broomcorn millet grows well in the dry inner Alpine Vinschgau Valley and appears to have been a main crop in this region.

Bean (*Vicia faba*) was found at sites located mainly in this northern part of the region (Table 4). Therefore, the explanation for this distribution pattern could lie in the wetter growth conditions in the north. The plants demand loamy and humus-rich soils, or sandy soils, if the precipitation is high enough (Butler 1992). The occurrences of pea (*Pisum sativum*) show no preferred distribution pattern in the area discussed. Additionally, the not so common foxtail millet (*Setaria italica*) and lentil (*Lens culinaris*) occur at some excavation sites and both species are concentrated to the south of the main Alpine range (Table 4).

The discussion of cultivated plants in the eastern Alps based on the chronological data set shows no distinctive distribution pattern. In general, further archaeobotanical investigations are necessary to obtain detailed information about the chorology of cultivated plants in the Alpine region.

The different regional distribution pattern of cultivated plants in the Alpine area seems to have been related to abiotic factors such as precipitation, temperature, soil conditions and altitude. Distinctions in the scale of arable production and the development of arable expansion have been recognized in parts of The Netherlands, Belgium, Luxemburg and France (De Hingh 2000). The conclusion could, of course, be used simply to redraw the dividing line between the north and south of the main Alpine range in central Europe, but this would maintain the simplistic use of broad generalizations and environmental determinism, without adding any understanding of social and cultural impact. For a further interpretation, settlement type, cultural influence, social status and trading systems should also be included.

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