Alpine influences on core crop package variation during the Neolithic:

The Prealpine case study of Trou Arnaud, a Chasséen agropastoral cave within the Diois (Drôme).

Freya Jane Greaves

Master of Arts (by Research)

University of York

Archaeology

December 2021

Abstract

This dissertation presents the results of archaeobotanical investigation into the Chasséen cave of Trou Arnaud (Diois) (c.4460-4040 BC) within the context of Neolithic core crop variety in and around the Alpine landscape. Cereal and legume crops were staples of the Neolithic subsistence economy across western Europe, essential to human diet and livestock management. However, despite the widespread importance of grains and pulses, agricultural practices were heterogenous and core crop preferences were variable, fluctuating based on cultural, socioeconomic, and environmental influences. This diversity was especially pertinent around the Alps. Particularly focusing on the adaptation of agrarian strategy in marginal mid-mountain environments, this dissertation aimed to understand the causes of diversity in Neolithic core crop packages. Broad-scale variation was identified through a spatial analysis of existing crop macrofossil data from the circum-Alpine landscape, while a reassessment of archaeobotanical macrofossils from Trou Arnaud acted as a case study into the role of crops on Prealpine agropastoral caves during the Chasséen. Although preferences towards certain crops appears partly culturally influenced, agricultural strategies were adapted to maximise resilience and ensure reliable yields within the challenging environmental and climatological constraints of the Alps. Inner Alpine sites often diverged from the practices of contemporaneous lowland groups, preferring hardier, more adaptable crops. Trou Arnaud presented a good example of this adaptation. While a predominance of *Hordeum vulgare* and *Triticum aestivum/durum/turdigum* was characteristic of contemporaneous Chasséen sites in southern France, glume wheats, particularly *Triticum monococcum*, were most significant at Trou Arnaud. This was perhaps in response to the harsh environmental conditions experienced in the Diois, including late frosts, strong winds, irregular precipitation, and the poor soil quality of the limestone slopes. Although the primary function of the cave remains enigmatic, a reliance upon crops by Prealpine communities is highlighted, and the integration of groups occupying marginal environments within the Chasséen agropastoral economy is supported.

Contents

List of tables

List of figures

Acknowledgements

Many thanks to my supervisor Dr. Kevin Walsh for all his consistent help and support throughout this project, to Dr Lucie Martin for her kind advice regarding all things archaeobotanical, alongside supplying the material and base dataset of sites, to Dr Ruth Pelling for generously advising with some identifications, and to my housemate Patrick Mayer for always being on call to talk Alpine archaeology. I would also like to thank my friends and family for keeping me smiling over the course of my Master's project, and to my furry friends Chuckie, Ruber, Elma, Harri, Bast and Oreo for the purrs and barks of encouragement.

Author's Declaration

I declare that this thesis is a presentation of original work and I am the sole author. This work has not previously been presented for an award at this, or any other, University. All sources are acknowledged as References and can be found in the Bibliography of this work.

Introduction

1.1. Aims and objectives

Advances in Alpine archaeology have highlighted a complex dynamic between Neolithic agricultural communities and the unpredictable and demanding landscape of the Alps. Through increasingly accurate climatological data, land cover models, isotope and aDNA analyses of human and animal remains, alongside traditional archaeological research, Neolithic communities are understood to have engaged with the environment diversely. Mountain environments influenced subsistence strategy, the exploitation of natural resources, and the movement of people, ideas, and material culture (Walsh & Giguet-Covex, 2019). However, the role of crops in past Alpine economies has historically been understudied, particularly in the southern and western Alps in which archaeobotanical remains are less common. The question of crop cultivation within mid-high mountain climates remains especially uncertain. Thus, further study into agricultural systems is necessary to develop a more holistic understanding of the influence of marginal environments in Neolithic lifeways and the development of farming. This dissertation aims to explore the relationship between the dynamic Alpine environment and Neolithic variability in agricultural practices on a regional scale, exploring spatial and temporal trends in existing crop data from the western Alps, and locally, through a case study of Middle Neolithic agropastoral strategy at Trou Arnaud, a mid-mountain cave within the Diois Prealps. This was achieved via the following research question and objectives:

Research Question

- To what degree did the environmental conditions of the Alpine landscape contribute towards variation in crop assemblages during the Neolithic in and around the western Alps?

Objectives

- **SO1:** To synthesise current archaeobotanical knowledge from the western Alpine region through the creation of maps in ArcGIS Pro, to identify spatial and temporal trends in crop package variation and agricultural strategy throughout the Neolithic.

- **SO2:** To analyse archaeobotanical data from Trou-Arnaud through the examination of macrofossils and subsequent identification of taxa, leading to a critical assessment of the character of agropastoral practices, human-environment interaction, and the socioeconomic role of crops in the Diois.

- **SO3:** To integrate archaeobotanical analyses from Trou-Arnaud into the context of the western Alpine Chasséen agropastoral economy, to investigate variety in farming practices based on site function, seasonality, and the relationship between agricultural landscape exploitation and altitude.

- **SO4:** To interpret these datasets to examine the influence of Alpine landscapes upon the development and adaptation of Neolithic agriculture, economy, and cultural identity.

1.2. Background to the study and rationale

1.2.1. Background to Trou Arnaud

Situated within the department of Drôme in the Auvergne-Rhône-Alpes, Trou Arnaud lies on the periphery of the western French Alps within a significant karstic network in the Diois valley, characterised by unstable geomorphology with steep slopes and fractured sedimentary rocks (Bravard *et al*, 2003). The Diois has traditionally been viewed as a barren and arid landscape; historical accounts noted that crop yields were meagre, and soils exceptionally degraded up to the 20th century (Sauvan, 1921). However, the area underwent an economic revolution following the introduction of new roads and chemical fertilisers in the 1900s, thus agriculture became a leading income source for the region (Sauvan, 1921). To contextualise the postmodern narrative of soil depletion and regeneration, it is important to develop a comprehensive history of agriculture and land exploitation in the Dios, underpinned by an understanding of how the first farming communities affected the landscape.

Today, Trou Arnaud consists of a cave complex comprising 1500m of dry and 700m of flooded galleries, however, only a small portion was accessible from the exterior during the Neolithic: the Galerie de Pots (Daumas & Laudet, 2012). This corridor, 85m long and up to 6m wide, was entered via a north-facing porchway at 720m altitude, situated over the banks of the Volvent stream within a deep, narrow gorge - the Roanne Valley. The internal temperature would have been stable, around 10-11^{o}C and relatively humid year-round. Archaeological remains, including pottery and charred grains, were discovered in 1952 during speleological topographic surveys, leading to the excavation of the exterior porch from 1986-1990 (Daumas & Laudet, 1988; 1998; 2012).

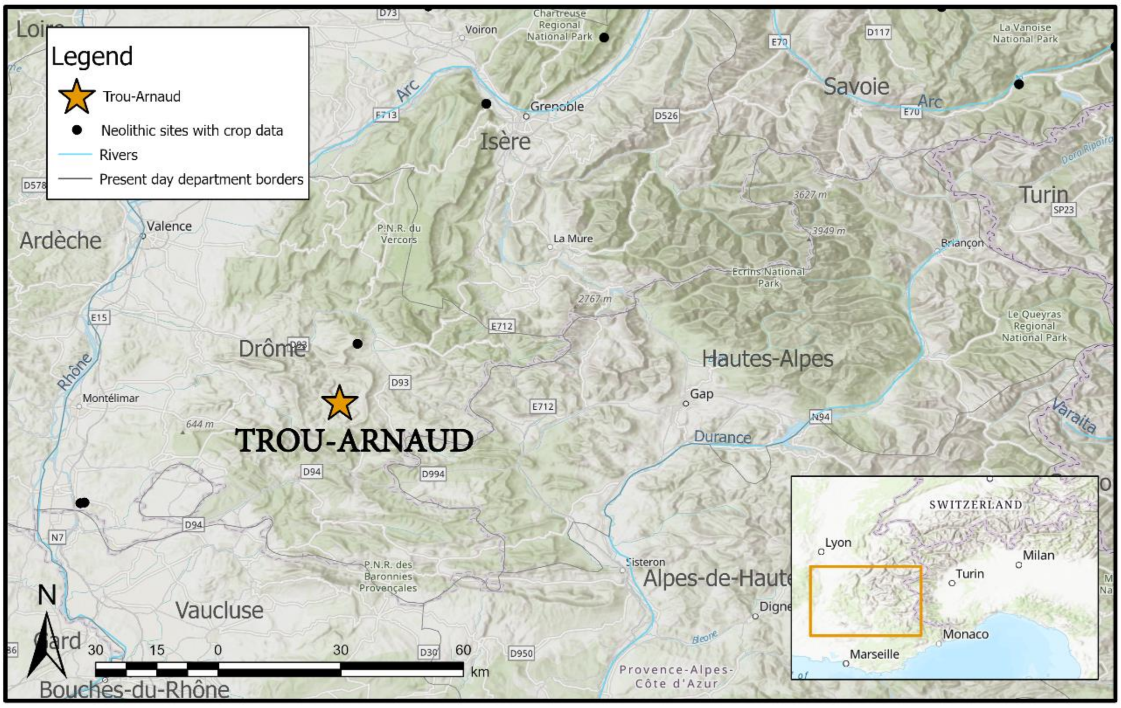


FIGURE 1. THE LOCATION OF TROU-ARNAUD WITHIN THE CONTEXT OF THE WESTERN ALPS.

The nearby landscape is presently comprised of pastoral slopes, clustered coniferous forest, and Valanginian marl-limestone outcrops and slopes; although the vegetational character would have differed, this was likely a fairly economically attractive environment during the Neolithic (Daumas & Laudet, 2012). Land exploitation opportunities for crop cultivation, pasturing of livestock, and hunting were available within a few kilometres of the cave, while after heavy rains a freshwater waterfall flows within the complex.

Nevertheless, notions of marginality remain relevant to Trou Arnaud. During heavy rainfall, the swelling of the Volvent river would have rendered the cave entrance near inaccessible, causing the gorge passageway to become narrow (Daumas & Laudet, 2012). Throughout periods of increased precipitation, accessibility would have been severely limited, raising queries regarding site function and the seasonality of occupation within the framework of Alpine mobile agropastoralism. Alongside the abundance of ceramics and cereal remains, uncommon in temporarily occupied pastoral sites, the traditional interpretation of Trou Arnaud as a sheepfold is rendered more complex, thus worthy of further study. The quantity of charred crop material recovered, unusually high for the region, provided a rare opportunity for quantitative analysis of cultivation practices, while the environmental limitations of the Diois are well-understood. Thus, Trou Arnaud was an ideal candidate for a detailed case study to facilitate testing of the hypothesis that Neolithic agricultural practices were adapted in response to the challenges of the Alpine environment and provide insight into the character of and motivations for adaptations.

1.2.2. Rationale: Gaps in knowledge of Alpine Neolithisation

The Alpine arc has traditionally been portrayed as a barrier to the process of Neolithisation, regarded as a 'marginal' environment, economically unviable and poorly suited to agricultural development (Mazzucco et al., 2019). Subsequently, the Alps have been depicted as a void on maps plotting Neolithic expansion into Europe, and their role in the dissemination of agricultural practices has been ignored. Moreover, modern notions of economic productivity have been imposed on mountainous environments in labelling them as marginal, resulting in limited archaeological interest and creating the illusion of an absence of past socioeconomic activity (Walsh et al., 2006). Today, more nuanced analyses propose that people, material culture, and ideas were slowly 'filtered' through the Alps (Trefny & Jennings, 2017). This study aims to provide insights into these interpretations by highlighting the presence of farmers within environmentally challenging regions and tracing the key pathways into the Alps as reflected by adaptations in crop cultivation practices. Furthermore, although crops provided an estimated 60-90% of calories to Neolithic populations in the northern Prealps, studies into agriculture have been largely eclipsed by research on animal husbandry (Baum et al., 2019). Analysis of crop remains complements existing research on livestock management to provide insights into a significant, yet often overlooked aspect of prehistoric daily life, diet, and land exploitation. Therefore, an increased focus upon archaeobotanical study is necessary to assess the resilience of Neolithic socioeconomic systems within diverse environments and climates and determine the scale of adaptation to subsistence strategy and culture that was required when adapting to life in the mountains.

Despite a resurgence in high-altitude paleoecological research, focused mainly on reconstructions of Holocene vegetation and historical ecologies, the past environments of the low-mid altitude Alpine foothills and Prealps in southeastern France have been largely overshadowed (Walsh & Mocci, 2011; Walsh, et al., 2014; Walsh & Giguet-Covex, 2019). Although partially attributable to smaller-scale industrial development and commercial excavations in this region, this is also due to a heightened research focus on northern Alpine lake settlements, in which organic material is often highly preserved, thus knowledge of the arable economies in the northern Alps has become higher resolution (Jacomet, 2006a; 2007; Martin, 2014). This research bias has led to an imbalanced understanding of Alpine human-environment interactions, in which Neolithic agricultural practices remain unclear in the southwestern Alps. This study aims to contribute towards a more holistic understanding of past Alpine plant economies and provide insights into agropastoralism in an understudied region: the Diois.

1.2.3. Rationale: Contributions to contemporary debates

Provided datasets are extensive and robust, paleoecological studies are uniquely placed to allow researchers to explore the intersection between the natural environment and human societies by quantifying long term effects of land use (Schwörer et al., 2015). Nevertheless, the nuances of human activity are difficult to identify, and interpretations tend to be generalised. Archaeobotanical studies can supply a focused, site-wide view, which may be contextualised within broader paleoenvironmental data to provide insights into local changes in the environment and subsistence systems. Archaeobotany bridges the gap between broad-scale climatological and environmental systems inferred from climate and land cover models, and specific site-wide responses, allowing a higher resolution understanding of human-environment interactions, with implications towards present-day discussions.

Throughout the Holocene, accelerating rates of erosion, soil degradation and flooding in the Alps have resulted from the overexploitation of pasture and intensification of weather events associated with climate warming (Bajard et al., 2020). Underlying the highly anthropically-influenced Alpine landscape experienced today, Neolithic forest conversion to agropastoral lands represented the first global episode of widespread human-induced terrestrial modification (Kaplan et al., 2011). Presently, unprecedented rates of global climate change have already begun to affect Alpine biomes on devastating scales. Notably, the frequency of extreme weather events has increased; in the autumn of 2020, Storm Alex led to flooding and landslides causing significant loss of life and property in the Alpes-Maritimes region (BBC News, 2020). Particularly, erosion-induced flooding poses a risk to communities in the lower Alpine valleys; to address this, research must examine the sustainability of contemporary and past land management practices (Bajard et al., 2020). It is hoped a deeper comprehension of the extensive past human influence upon Alpine ecosystems can contribute towards well-informed decisions in contemporary Alpine land management, promoting resilient and sustainable land use.

1.3. Methodological overview

This analysis used two complementary methodologies to provide insight into the character of the earliest agricultural practices in and around the Alps on both a regional and local scale: this included spatial and temporal analysis using a quantitative dataset and mapping functions in ArcGIS Pro, and a case study using traditional methods of archaeobotanical analysis. Firstly, existing archaeobotanical data from 88 sites in the Alpine and circum-Alpine region were synthesised in Microsoft Excel, and plotted into maps using ArcGIS Pro. This data was used to assess spatial and temporal variation in crop packages, including the distribution and frequency of specific crops in relation to environmental conditions, the Neolithisation process, archaeological cultures, and agropastoral economies. Secondly, carbonised plant macrofossils from the Chasséen cave of Trou Arnaud were identified and quantified by context. This data was tabulated using Microsoft Excel and represented by graphs and charts to facilitate investigation into agricultural strategy at Trou Arnaud, its role within the Chasséen agropastoral economy, and the influence of the Diois environment on these practices.

1.4. Dissertation outline

This dissertation attempts to understand the causes of variation in Neolithic agricultural practices through an assessment of Alpine archaeobotanical data; the effect of mountain environmental conditions is highlighted through new analyses of macrofossils from Trou Arnaud. Chapter Two provides a synthesis of the current literature regarding the Alpine environment and climate throughout the Holocene, theories in broader European and specifically Alpine Neolithisation, and existing archaeobotanical datasets. The methodologies employed in the new archaeobotanical analysis, and the spatial assessment of existing botanical data are described in Chapter Three. Spatial and temporal variation in Alpine agricultural practices is explored in Chapter Four; collated macrofossil data relating to the core Neolithic crops is synthesised, and the possible causes of crop package diversity, including mountain cultivation, are discussed. Chapter Five presents the results and interpretation of macrofossils from Trou Arnaud, including the possibility of a local mid-mountain cultivation and the cave's role within the Chasséen agropastoral economy. The resulting conclusions are summarised in Chapter Six with recommendations for future research.

2. Key themes in Neolithic Archaeology and the history of arable farming

2.1. Aims and structure of the chapter

When discussing the reasons for variation in early agricultural practices in the Alps, research must be well-grounded in an understanding of the influencing factors, including climatic fluctuation, environmental conditions, cultural development and the dissemination of the Neolithic, and any prior research into prehistoric Alpine farming. To achieve this, a literature review has been compiled regarding: climatic and anthropogenically induced environmental change in the circum-Alpine zone, theories on the Neolithisation process in western Europe and the Alps, current archaeobotanical data from the Alpine region, and an introduction to the site of Trou Arnaud.

2.2. Changing environments and human adaptation – from the Mediterranean to Northern Europe, by way of the Rhône Valley and the Western Alps

2.2.1. Key themes and issues

The notion of environmental marginality often emerges as a key theme in Alpine archaeology, in which the extreme environmental conditions have influenced the development of culture and economy (Walsh, 2005; Carrer et al., 2020). Historic environments have mostly been inferred through palynological and anthracological studies, although limitations with these methodologies must be noted. Pollen data suffers from contamination from higher mountain stages, having floated downwards, but also from lower levels due to upwards winds, while charcoal from archaeological sites may not accurately reflect natural vegetation, as firewood procurement is culturally biased (Walsh, 2014; Delhon, 2018). However, these issues can be mitigated by cross-referencing numerous data types. The ecological and cultural influences in subsistence strategy are similarly a common theme, reflected in spatial and temporal variation in the character of arable farming, pastoralism, and hunter-gathering. Subsequently, the adaptation of agricultural strategies towards different regions of the Alpine landscape has become an important topic in Alpine paleoenvironmental research, including variety in crop choice, exploitation of altitudinal stages, and agropastoral systems, although the scarcity of data from the southern Alps affects interpretations.

2.3. Holocene environmental variation with a focus on Neolithic farming as an adaptation to the environment

2.3.1. Broader Western Europe

The Holocene climatic optimum represented a period of mean temperature stability, modulated by warming in northern Europe and cooling in southern Europe between 7000-3000 BC, followed by generalised, gradual continental cooling (David et al., 2003). Early Atlantic (6900-4700 BC) vegetation cover was dominated by homogenous broad-leafed, deciduous forest, declining to extremely low levels in the present day (Fyfe et al., 2015). Following relative climatic stability in the preceding two millennia, around 4000 BC in the Middle Neolithic there began widespread forest conversion to a mosaic of open arable land, pasture, woodland, and heath. The accelerated deforestation is commonly attributed to anthropogenic influences, although its onset may have coincided with a brief cooling event (Berger, 2003; 2005; Berger et al., 2019). Contemporaneously, Mauri et al. (2015) identified patterns of increased summer precipitation in southern Europe throughout the Holocene, accelerating between 4000-2000 BC, reflected in the damp conditions illustrated by vegetation reconstructions of southern France (Berger et al., 2019).

2.3.2. The Alps

Alpine vegetation is best divided based on altitude; plant cover varies between altitudinal stages, losing diversity and cultivability when increasing in altitude, concomitant with decreasing temperature and increasing precipitation (Theurillat and Guisan, 2001; Fauquette, et al., 2018). Ozenda (1988) classified three present-day bio-geographical regions according to climate, altitude and geology: the Alpine fringe, consisting of the lower massifs, such as the Diois, and characterised by carbonates and *Fagus* forest, and the inter-Alpine and continental pole zones, both characterised by higher peaks and silicates, with *Abies* and *Picea* forests respectively, alongside *Pinus* forest in the southwestern Alps (Pecher et al., 2011). However, these classifications do not consider variation over time, or regional differences caused by human influence. Mostly corresponding with Ozenda's (1988) Alpine Fringe, the subalpine zone represents approximately one third of the Alps today, comprising diverse topographies and climates on mostly limestone massifs; many subalpine areas have fluctuated between Boreal and Alpine Köppen-Geiger climate classification zones over the Holocene (Martin, 2014; Walsh and Giguet-Covex, 2019). Notably, the character of the Prealps varies longitudinally, rather mountainous in the southwest, while the northern region comprises flat wetlands, peat bogs and lakes, rising steeply into the Alpine mountains (Martin, 2014). The Alpine landscape continues to be agriculturally marginal today, in which the Prealps are a transitional landscape between the fertile soils of the surrounding plains and valleys, and harsh mountain environments (Estel et al., 2016). Consequently, an understanding of the environmental conditions experienced by early farmers is necessary to understand the challenges to existing agricultural strategy posed by the climate of the Alps and surrounding regions.

Lake level data and pollen analysis of lake cores have been useful in reconstructing climatic conditions throughout the Neolithic (Magny, 2004; Fyfe et al., 2015), while much palynological and anthracological literature was synthesised by Martin (2014). Shortly preceding the start of the Alpine Neolithic, the 8.2k BP climatic degradation event disrupted the stability and warmth of the Holocene Optimum in the global northern hemisphere; subsequently, increased humidity was attested in the northern Alps, by decreasing *Corylus* levels, and an expansion of taxa indicative of damp conditions, including *Pinus*, *Abies*, and *Tilea*, and *Quercus* in the Prealpine zones (Martin, 2014; Li et al., 2019). Similarly, humidity-preferring *Fagus* populated the western French Alps, Rhône Valley, and the Valais, while *Abies* delimited the southern Alpine treeline alongside *Pinus sylvestris*, intermittent with periods of heathland scrubs (Martin, 2014).

The Mid Holocene in the Alps was marked by complex patterns of wet to dry oscillations occurring over short periods throughout the Recent Atlantic (4700-3500 BC), within overall trends of climatic degradation and humidity (Magny, 2004; Martin, 2014; Walsh et al., 2014). *Fagus-Abies* forest gradually replaced mixed deciduous woodland at low-altitude, although coniferous needle leaf forest dominated higher altitudes until 2500 BC, also remaining common in the cool environments of the

Prealps (Fyfe et al., 2015). As such, *Taxus baccata* expanded at mid-high altitude in the northern Alps, while *Pinus* remained important across the western Alps (Giguet-Covex, et al., 2011; Martin, 2014). Even so, sedimentological studies nuance this narrative, suggesting forests remained relatively open in the southern Alps due to the steep topography and fragile geological substratum (Beeching et al., 2004). The Recent Atlantic also observes the start of significant human influence on vegetation. Southern Alpine tree cover reflects this from 5000 BC; *Abies* levels began to decline, accelerating from 4000 BC, leading to localised extinctions below 1000m, while broadleaved woodland diminished at faster rates than the continental average (Walsh, 2014; Walsh et al., 2014; Fyfe et al., 2015). The expansion of ruderal and nitrophilous taxa indicates forest clearance and pastoral expansion, supported by the proliferation of *Fagus*, a pioneer species of disturbed land, from 3800 and 2700 BC in the southern Prealpine and montane mountain stages (Ozenda, 1988; Walsh et al., 2014). Notably, lake level data suggests Neolithic technological developments and new ceramic and lithic typologies often emerged during cool, damp oscillations, denoting the disruption of socioeconomic systems by environmental change (Magny, 2004). However, human-induced environmental change was small-scale; Neolithic activity was low-impact in the high Alps, with agropastoral activity concentrated in valleys and foothills. Nevertheless, some evidence for high-altitude forest conversion at was observed in cores from Lac du Lauzon, Ecrins, at 1980m as low-pollen producing ruderal taxa steadily increased from 4250 BC and cereal pollen from 3450 BC (Argant, et al., 2006; Walsh et al., 2014).

2.4. The Environment of the Study Region and Middle RhôneValley

The Middle Rhône Valley (MRV) is a region of climatic convergence between Mediterranean, Alpine and oceanic biomes, representing a transitional zone between the Mediterranean climate in the Lower Rhône and the continental ecology of the northern Saǒne, bordering Atlantic and Mid-European bio-geographies (Olivier et al., 2009; Berger et al., 2019). Today the northern limit of olive production, signalled by colder temperatures and wetter summers, demarcates this (Berger et al., 2019). Abutting the western Prealps, the landscape of the MRV never exceeds 600m altitude, including alluvial plains, quaternary terraces, moraines, and many lakes and marshes, especially in the northern areas (Berger et al., 2019). The Neolithic MRV climate was supra-Mediterranean, while vegetation and landscape usage varied between the foothills and alluvial basins. Lands were easily cultivable, however, herbaceous and crop macrofossil data is low resolution beyond the karstic hills and Prealps, with preservation limited by intensive hydrological activity in the plains (Brochier, 1997; Delhon et al, 2009; Berger et al., 2019). Consistent exploitation of the lower-lying regions from 6400-5600 BC, 4900-4500 BC, and 3600-2800 BC, reflects Neolithic expansion of lowland pasture while forest persisted in the Prealps, intermittent with periods of decreased activity possibly related to climate cooling episodes (Beeching et al., 2004).

Trou Arnaud lies alongside the Roanne stream, a tributary of the Drôme, in the Diois - a Prealpine landscape between the western Alps and the MRV. This area is characterised by continuous limestone karstic hills between 500 and 2000m, conducive to caves and rock shelters (Berger et al., 2019). The region is somewhat enclosed by the steeply cliffed Vercors massif to the north, and the peaks of the Dévoluy and Bochaine massifs to the east (Gidon, 2016). Biogeographically described as supra-Mediterranean and mountain-Mediterranean, the Diois is a transitional climatic zone into the cold, humid, northern Alps, being relatively humid due to its altitude although a visibly drier landscape than Vercors (Blanchard, 1918). Understanding of the Middle Neolithic environment derived mainly from pollen and charcoal data from cave sites, and sedimentological data from the alluvial cone of the Drôme, downstream from the Diois river.

Pollen and charcoal data from the Neolithic to Bronze Age sheepfold of Antonnaire, around 1200m altitude and 15km north of Trou Arnaud, was sampled by Argant et al. (1991). Chasséen to Late Neolithic deposits show a diverse vegetation dominated by *Quercus*, alluding to a humid climate in the Diois (Argant et al., 1991). Furthermore, the presence of ruderal and cereal pollen suggests local crop cultivation by 4000 BC. Notably, only light-loving flora are represented, denoting an open environment by the Chasséen following intensified deforestation, with *Juniperus* dominating by the Early Bronze Age (Argant et al., 1991). Despite the small charcoal sample size, similar conclusions were drawn at Trou Arnaud (Daumas & Laudet, 2012). Wider anthracological data from the Diois suggest altitudes around 1750m were consistently occupied by *Pinus* across the Holocene (Thiebault, 1999). Humidity is also reflected in the expansion of *Taxus baccata* across southeastern France from 5500-5000 BC (Martin & Thiebault, 2010). The Middle Neolithic treeline was located around 2000m altitude, higher than today, suggesting a mild climate in which crops could be cultivated at the mid-altitudes (Argant & Argant, 2000).

Palynological and sedimentological data from the alluvial cone of Drǒme supports this; evidence for forest fires between 6000-5000 BC marked the onset of Prealpine anthropogenic deforestation, where subsequent pasturing prevented the regeneration of dense forest (Brochier et al., 1991). This corresponds with the decline of *Ulmus* and *Tilia* from 4000 BC, while possibly also attributable to their intensive exploitation for fodder, reducing the young branches, thus the frequency of pollen produced (Brochier et al., 1991). This coincides with increasing representation of light-loving trees, grassland taxa and cereals, reflecting the expansion of local agriculture and pastoralism (Argant et al., 1991; Brochier et al., 1991).

2.5. The transition to farming either side of the Alps

Emerging in the Near East around 10,000 BP, the new technologies, economy, and lifeways of the Neolithic spread across Europe over the following 5000 years (Weisdorf, 2005). Based on novel food production strategies and the spread of domesticated animals and crops, these changes drastically altered daily life responsibilities, diets, economic structure, and human perception of and interaction with the natural world (Mazzucco et al., 2017). The Neolithic is traditionally interpreted as disseminating via 'Neolithic package,' including farming practices, domesticated animals and plants, ceramics, timber and dry-stone houses, generalised storage and demographic increase (Tresset & Vigne, 2011). Domesticates including *Triticum dicoccum*, *Triticum monococcum, Triticum aestivum/durum/turgidum, Hordeum vulgare, Pisum sativum*, *Cicer arietinum*, *Vicia ervilia*, *Lens culinaris*, cattle, sheep, goat, and pig, alongside dairy products, expanded dietary variety, complimenting hunted and gathered foodstuffs (Tresset & Vigne, 2011). Subsequently, labour transfers away from food procurement allowed occupational specialisms to develop, catalysing the development of new technologies, such as metallurgy, alongside centralised and hierarchical societal structure (Weisdorf, 2005).

Synthesis of Neolithisation models of western Europe has established this process was multifaceted and regionally varied, mostly disseminated via migration (demic diffusion), while cultural exchange (cultural diffusion) comprised around 40% of diffusion (Fort, 2012). Tracing the pace of spread through radiocarbon data, Fort (2012) highlighted slower rates in northern Europe, the Alps, and the western

Black Sea region. The slower pace was suggested to denote cultural diffusion, although in the case of the Alps this may relate to the less hospitable climate. Neolithic transitions were more rapid in southern and eastern Europe, indicating a migration-based Neolithisation (Gkiasta et al., 2004) Although it is possible demic diffusion in northern Europe comprised communities migrating at a slower pace, Sampietro et al. (2007) noted a higher concentration of Neolithic genetic markers in early Mediterranean farming populations, supporting a north-south divide between dissemination methods. Interestingly, a combination of both methods is suggested for the Alps. More environmentally challenging regions necessitated a 'transitional period' between Mesolithic-Neolithic lifeways; Perrin (2003) concluded Mesolithic groups coexisted alongside Neolithic communities into the Middle Neolithic in the Jura, based on the stratigraphic cooccurrence of Mesolithic lithics and Saint-Uze Early Neolithic ceramic. However, these interpretations were localised to the Jura, while material culture may not accurately reflect past identities or realities.

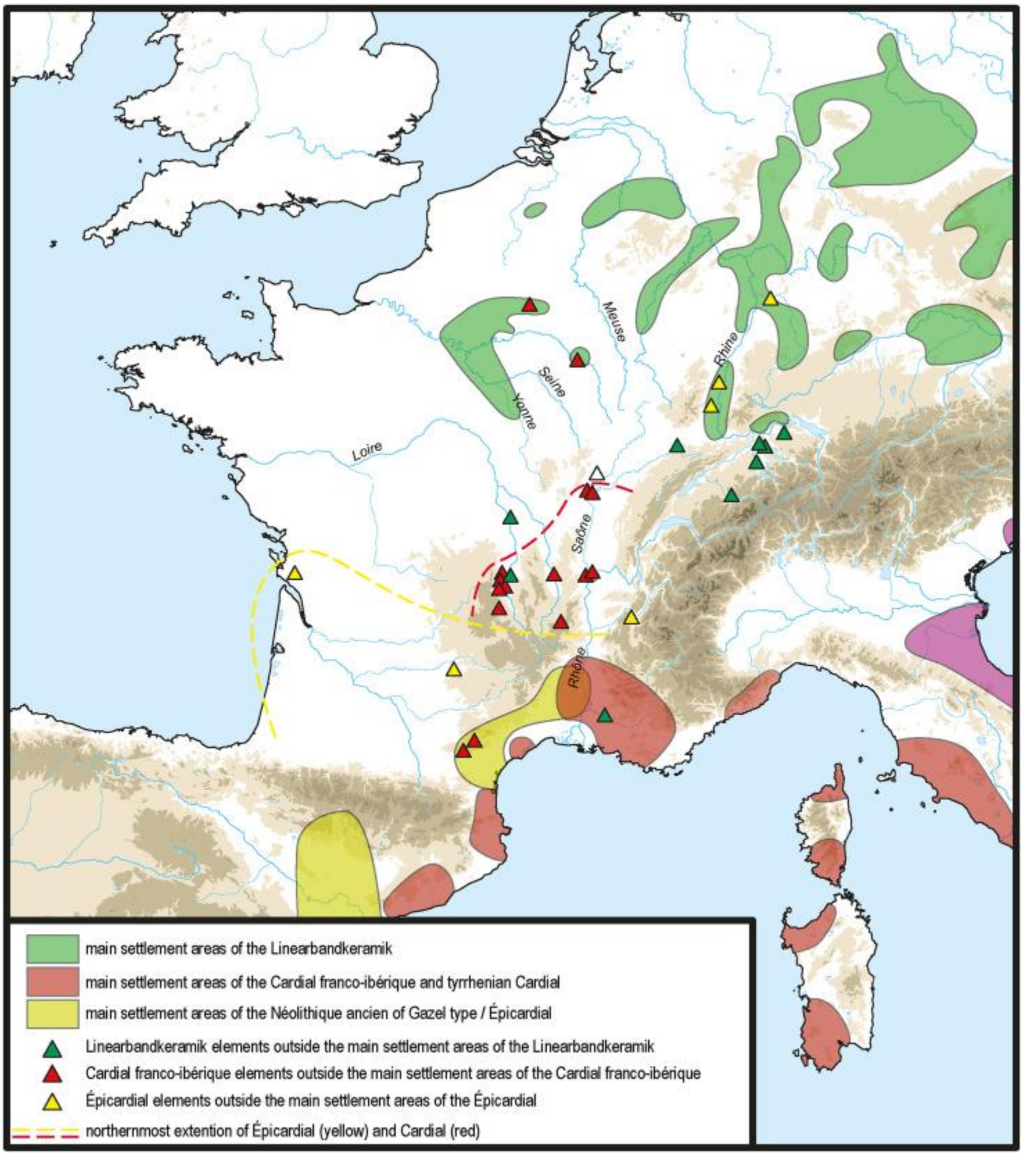


FIGURE 2. MAP ILLUSTRATING THE EXTENT OF LINEARBANDKERAMIK, CARDIAL, AND EPICARDIAL ARCHAEOLOGICAL CULTURES IN WESTERN EUROPE DURING THE EARLY NEOLITHIC (WILLIGEN, 2018).

Occurring in multiple phases and dividing into numerous subcultures, two main routes were taken in the dispersal of the first Early Neolithic farmers into Europe, corresponding with the emergence of two cultural spheres (Guilaine, 2001; Bocquet-Appel, et al., 2009). These were the Linearbandkeramik and its associated cultures along the Danubian current, and the Impressa/Cardial cultures and their derivatives along the northern Mediterranean coast (see figure 2) (Zvelebil, 2004; Rivollat, et al., 2015). Linearbandkeramik culture was characterised by vessels with spiral motifs, adzes, and longhouses, alongside a dominance of hulled wheats (*T. monococcum* and *T. dicoccum*) and concentrated around areas of fertile loess soil (Jacomet, 2007; Willigen, 2018). The situation along the Mediterranean coast was more complicated. Characterised by impressed and incised ceramics, the Impressa/Cardial culture emerged around 6000 BC in Greece, traveling rapidly to southern France in 5800 BC (Gernigon, 2016). The Mediterranean package differed, comprising a preference of ovicaprids over cattle, the dominance of *T. monoccocum* and *T. dicoccocum* – although *T. aestivum/durum/turgidum* was popular in the Cardial/Epicardial -, greater architectural variety, and widespread use of obsidian (Jacomet, 2007; Gernigon, 2016; Willigen, 2018). After 5300 BC, the Epicardial tradition emerged, separated by the French Central Massif, stretching to Iberia, and conventionally interpreted as a later phase of the Cardial with the influence of indigenous groups (Manen, 2002; Willigen, 2018). Nevertheless, with interpretations based on ceramic typologies, how far cultural differences permeated into lifeways is unknown.

Although the basic structure stands, the dual current model is simplistic, lacking nuance into subcultures and phases of accelerated and decelerated spread (Jacomet 2007; Martin, 2014). For decades this model was unchallenged, suggesting limited interaction between the spheres - the Alps acting as a 'no man's land' between them. However, it is now considered that Linearbandkeramik and Cardial groups were well connected, in which Alpine passes acted as highways between spheres, while the Rhône River was an important route in the western European landscape (Olivier et al., 2009; Willigen, 2018). This is evident through the hybridised ceramics of Limburg and La Hoguette in the Lower Rhine, combining elements of Linearbandkeramik and Mediterranean typologies, and recurrent isolated Lineakbandkeramik material culture finds or exotic crops in Cardial zones and vice versa, signifying contact and exchange throughout the Early Neolithic (Jacomet, 2007; Willigen, 2018).

2.6. The transition to farming in the Alps

The Alpine environment and character of altitudinal stages has influenced subsistence strategy since the Mesolithic, in which hunting camps were positioned by the treeline (Walsh & Giguet-Covex, 2019). Even today, the significance of vertical mobility is evident in the unique practice of 'Alpine farming': the summering and dairying of livestock on high-altitude pasture, and wintering in lowland stables (Gilck & Poschlod, 2019). This differs from conventional transhumance, comprising highland summering, and wintering in lowland pasture, generally necessitating movement over longer distances. Integral to many Alpine cultural identities, Alpine farming encourages sustainable land use, particularly regarding vegetation, erosion, and biodiversity (Marini, et al., 2011; Cocca, et al., 2012). Originating in prehistory and first identified in the Bronze Age, a comprehensive agropastoral history of the Alps must be developed to gain a holistic understanding of human influence on this landscape (Carrer, 2015).

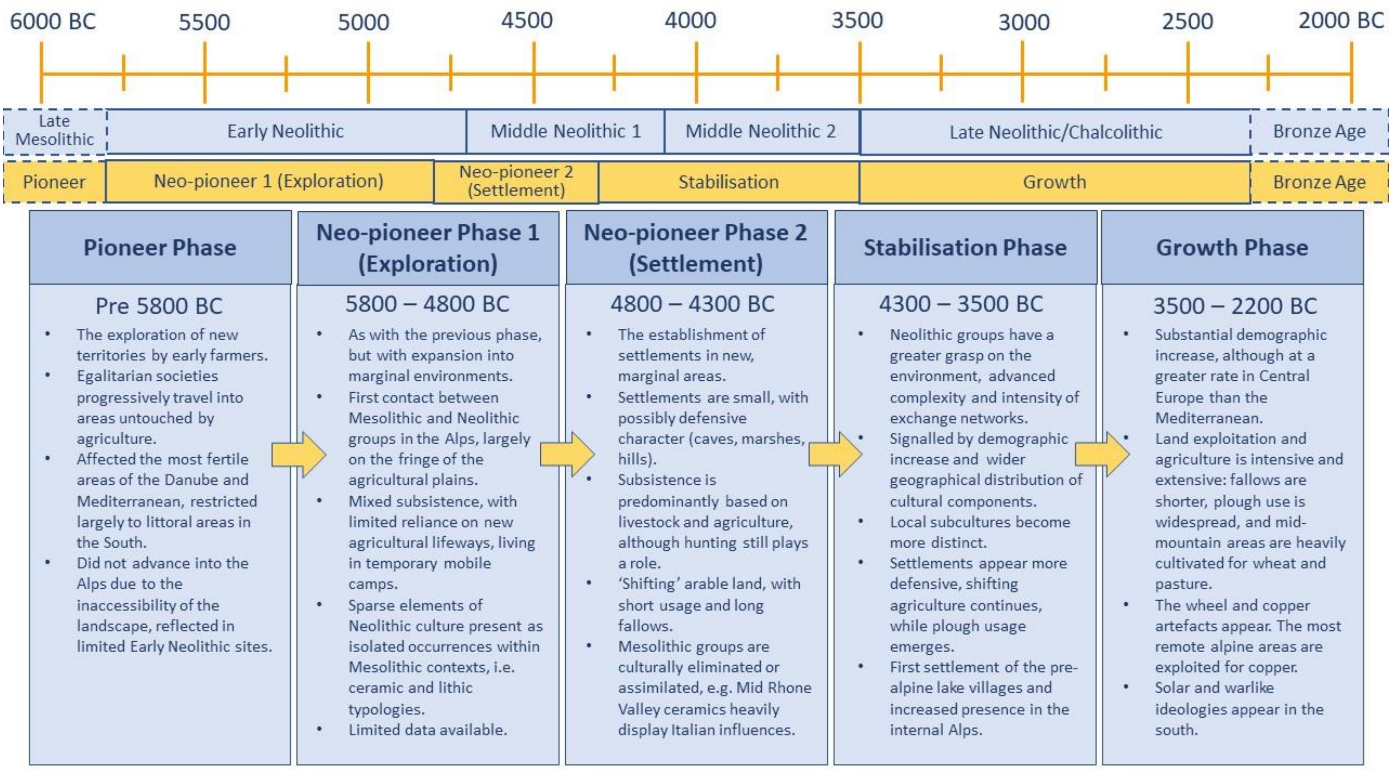


FIGURE 3. TIMELINE OF STAGES IN ALPINE NEOLITHISATION (AFTER GALLAY, 1990).

The Neolithisation of the Alpine region demonstrates the need for nuance within the generalised framework of the dual current model. An environmentally challenging landscape, the Alpine environment demanded significant adaptation to the lifeways of migrating Neolithic populations. Thus, the timeline of Neolithisation lagged behind lowland developments, while mountain sites held a greater degree of specialisation (Gallay, 1990). Gallay (1990) highlighted the arrhythmic nature of Mediterranean and Alpine Neolithisation through quantitative modelling using radiocarbon data, and identified specific phases within this process (Voruz, 1990). This model was based on Alexander's (1977; 1978) concept of frontiers, in which a 'shifting' border indicates the exploration of new territories with virgin land, while 'stable' borders denote the occupation of all usable land at their ecological limits. Gallay (1990) theorised marginal Alpine environments are characterised by shifting borders for longer than easily adaptable lowland areas, indicated by the longevity of Mesolithic technology and material culture into the Neolithic era. Alpine Neolithisation was subsequently divided into phases to provide a useful chronology for the Alps, MRV, and northern Italy (see Figure 3). However, assuming a degree of blurring between phases and regional variability, dates cannot be considered as concrete.

Dating to the Early Neolithic, assemblages comprising both Mesolithic and Neolithic material culture were recovered between 6000-5000 BC in the circum-Alpine region, representing a lowland zone of established settlement while the Alps were initially explored. Cardial ceramics represented much material south and west of the Alps; Guilaine and Manen (2007) suggest stylistic influences can be determined from both Neolithic migrants of the Italic Tyrrhenian Cardial and indigenous Mesolithic cultures of southern France. This evolved in tandem with the Epicardial, eventually becoming the dominant culture of southern France and the Rhône Valley by 5250 BC, attributed to demographic increase, marking a more unified Neolithic in southern France that extended to the Alps - with influences observed at Grande Rivoire, Isère (Guilaine and Manen, 2007; Manning et al, 2016). However, these cultural distinctions are determined near exclusively by ceramic typologies.

Meanwhile, determining the initial Neolithic occupation of the Alps is difficult; a hiatus of archaeological material in Prealpine caves between the final Mesolithic Castelnovian in 6340 BC and the first Neolithic evidence from Vercors around 5600 BC limits interpretation (Berger & Guilaine, 2009). Nevertheless, a Mediterranean route into the western Alps can be traced. Although Impressa sites are limited, confined to the coastal area, Cardial and Epicardial ceramic and lithic traditions spread up the Rhône Valley into the Drômese Prealps (Beeching, 2003; Vander Linden, 2011). However, Alpine Neolithisation is sparsely represented during the Early Neolithic, present as generally isolated elements of Neolithic material culture within Mesolithic assemblages in the foothills; in contrast Cardial agricultural sites are concentrated in the MRV lowlands by 5500 BC (Voruz, 1990). Furthermore, hunting persists as the primary subsistence strategy at altitude; while a mixed livestock was farmed in the Cardial/Epicardial plains and cattle in the LBK foreland, wild fauna dominates Alpine assemblages until the Middle Neolithic, when the first evidence for Alpine pastoralism emerges (Guilaine & Manen, 2007; Vander Linden, 2011).

Alpine settlements became established by the Middle Neolithic 1 around 4800 BC, increasing in frequency and stabilising following 4300 BC in the Middle Neolithic 2; henceforth, the number of Alpine sites increased dramatically, particularly Prealpine caves and later the northern Prealpine lake settlements (see figure 3) (Voruz, et al., 1995; Martin, 2014). Cultural developments continued to spread northwards from the Mediterranean; evolving from the Cardial/Epicardial traditions, the Chasséen dominated southern France from 4400-3500 BC, travelling northwards through the Rhône Valley, while the St Uze tradition emerged from the Cardial in the northern Alps and French Jura (Beeching, 2002; Vander Linden, 2011; Martin, 2014). Local sub-groups become more numerous and distinct; however, this may be exaggerated due to the greater volume of evidence compared to the preceding periods. On the northern Alpine foreland, the Michelsberg Kultur derived from the LBK, later developing into the Pfyn and Cortaillod traditions, while the Lagozza and Vasi a Bocca Quadrata (VBQ) cultures bordered the Alps from northern Italy (Vander Linden, 2011; Martin 2014). The concept of material 'archaeological cultures' being used to define prehistoric group identities was recognised as flawed by Vander Linden (2011); the Chasséen and Michelsburg cultures were particularly highlighted as demonstrating little homogeneity in material culture, including diverse funerary practices and lithic industries (Beeching, 2002). While 'archaeological cultures' are useful in chronologising and relative dating, they are not always accurate proxies for past identities, and interdisciplinary studies are required to identify localised identities and differences in lifeways (Demoule, et al., 2005; Vander Linden, 2011). Nevertheless, throughout the Middle Neolithic socioeconomic change is observed in the Alps. The specialisation and altitudinal organisation of sites developed; lowlands comprised large, enclosed settlements and agricultural plains, while at altitude sites held defensive properties alongside mid-mountain pasture and sheepfold sites (Beeching, 2003; Vander Linden, 2011). This initial exploration of high-altitude regions was likely motivated by the scope for raw material collection, namely flint deposits (Martin, 2014). However, regarding Gallay's (1990) model, remote alpine regions, such as the Upper Rhône Valley remained in earlier exploration and settlement phases (Perrin, 2003).

With regards to the study area of the western Alps, some studies have been conducted into the character of farming during the Middle Neolithic. Indicated by an increase in nitrophilous plants and a lowering treeline, pasture significantly expanded during the Middle Neolithic in the western Alps (Walsh et al., 2014; Carrer, 2015). Brochier et al. (1999) collated sediment data from southwestern Prealpine cave sites to explore their role in Chasséen agropastoralism; it was suggested herds were stabled and foddered in caves overnight, then natural or deforested mid-mountain pasture was exploited during the day. Faunal remains supported this interpretation, suggesting their exclusive, cyclical use for stabling and birthing, while lowland open-air sites held more diverse roles in cattle and ovicaprid management (Bréhard, et al., 2010; Bréhard, 2011). However, agropastoral strategies were regionally and culturally diverse; caves played a significant role in the Diois-Baronnies Chasséen, but were rarely occupied in Vercors, despite their greater geographical frequency (Brochier et al., 1999). Further integrated research between cave and open-air sites may aid understanding of the significance of site types and altitudinal zones in Neolithic agropastoral systems (Bréhard et al., 2010).

By the Late Neolithic around 3500 BC, the Alpine Neolithic was characterised by population growth, more concentrated, larger sites, long-distance trade, and technological development, while all altitudinal stages were exploited (Gallay, 1990; Walsh & Giguet-Covex, 2019). Neolithic influence upon the landscape intensified, as Alpine pasture was expanded, and remote regions were frequented for travel, raw resources, and mining following the development of copper (Bourgarit, et al., 2008; Walsh & Giguet-Covex, 2019). Alongside an increasingly generalised use of mid-altitude zones, pollen levels attest to high-elevation exploitation, with pasture up to 2000m in the French Alps indicated through forest clearance and a reduction in the treeline (Walsh et al 2014; Walsh & Giguet-Covex, 2019). Three long-distance metal exchange circuits developed, distinct between the northern, western, and southeastern Alps (Dolfini, et al., 2020). However, trade appeared limited to exotic material culture and new technologies; village economic systems and agriculture remained based on self-sufficiency, not generating surplus beyond community requirements (Gallay, 1990). Archaeological cultures became increasingly numerous, including the Luscherz-Auvernier and Horgen cultures on the Swiss plateau and the Clairveaux and Chalain on the Jura, but bound by flint and metal exchange networks (Martin, 2014). The western Alps retained a distinct Alpine identity; although ceramic traditions were influenced by Central European Corded Ware traditions, local forms dominated, perhaps attributable to a degree of geographical and cultural marginality (Gallay, 1990; Hafner, et al., 2017).

2.7. Alpine and Subalpine Farming and Land Management: A synthesis of published sites from the Alps

Although archaeobotany suffers from the inaccessibility of grey literature and limited data sharing, two developments have been especially useful to archaeobotanists studying the broader European Neolithic (Lodwick, 2019). Firstly, the EUROEVOL dataset is accessible and extensive: an open-access collation of c.8300 records for over 1500 taxa across Europe spanning 8000-4000 BP (College, 2016). However, some data is unreliable, including qualitative data from early excavations where context and sampling strategies are unknown, while regional syntheses can quickly become outdated. The Arbodat database takes a more regulated approach, in which European researchers contribute archaeobotanical data from all periods using standardised nomenclature for taxa, preservation conditions, features and archaeological period, into the centralised, well-maintained database (Kreuz & Schaffer, 2002). However, although data is high quality, the reliance on data-sharing means this resource is not comprehensive, while the minimal entry standard excludes much past research. Additionally, the database remains difficult to access for junior researchers or from other disciplines.

Specific to the western Alps, Neolithic botanical data is relatively limited, and there have been few broad-scale data collection efforts; thus, archaeobotanists rely on syntheses of isolated or small-scale studies. Martin (2014) provided the most comprehensive exploration of Neolithic archaeobotanical data from the Alps. Original macrofossil analysis was undertaken from four sites in the northern French Alps and contextualised within existing archaeobotanical knowledge from the western Alps; Martin (2014) subsequently explored the possibility of cultivation at altitude, the character of human-environment interactions and agriculture in and around the Alps, and the role of specific sites and environments within Neolithic agropastoral economies. The plausibility of mountain cultivation was noted although could not be undeniably discerned due to the broad growing conditions of the associated weed assemblages and possibility of numerous external factors influencing morphometric variation in grains, while both cultivated and wild flora were highlighted as holding important roles in the Neolithic plant economies, diets, and livestock management. Although mostly focusing on the northwestern Alps, this dataset and synthesis is invaluable and remains mostly up to date. However, beyond Martin's work, limited paleoenvironmental research has considered the adaptation of agricultural strategies within the Alpine environment, instead focusing on regions beyond the mountains, livestock management or natural vegetation history. Also concerning the northern Alps, Jacomet (2007) collated data from regions surrounding the northern Prealpine lakes to illustrate the evolution and diversity of Neolithic plant economies; an in-depth picture was developed, highlighting how the choice of core crops reflected the movement of populations and cultural development.

The sparsity of botanical studies from the southern Alps means fewer comprehensive syntheses have been published. These are mostly regionally and temporally focused syntheses in which the Alps are peripherally considered. Bouby et al. (2020b) collated Early Neolithic archaeobotanical data from southwestern France, including the western Rhône Valley, to explore variation in wild and domesticated plant resources within the Mediterannean bioclimatic region; this is valuable for comparison with Alpine data, although only adjacently relevant. Regarding the Middle Neolithic, Martin et al. (2016) compiled Chasséen plant data from eastern France to explore agricultural variation, with particular reference to cereal cultivation; while some Prealpine sites are included, most data is from Languedoc and the Rhône valley. Similarly, Bouby et al. (2020a) summarised data from the Late Neolithic around the southern Massif Central; the Alps were peripheral although briefly considered in this analysis. More generally, the BRAIN network provides a database of Italian archaeobotanical data across all periods, covering the Italian Alps and the Po Plain forelands, while the aforementioned EUROEVOL dataset contains useful, although infrequent, Alpine data (Colledge, 2016; Mariotti Lippi, et al., 2018). All syntheses note irregularity in the quality of data, and have, except EUROEVOL, excluded those of especially small volume or uncertain date, contributing to the scarcity of Alpine data. Cereal remains, present as caryopses or threshing remains, are represented at all sites considered throughout this synthesis in varying frequencies and preservation states. These are mostly represented by *Triticum monococcum*, *Triticum dicoccum*, *Triticum aestivum/durum/turgidum*, and *Hordeum vulgare* alongside legume crops, *Pisum sativum* and *Lens culinaris*, and oil-producing crops, *Papaver somniferum* and *Linum usitatissimum* (Jacomet, 2007; Martin, 2014).

Macrofossil data from the western Alps is concentrated around certain regions, while studies beyond these areas are more isolated. Almost half of Alpine sites with botanical data are clustered around the northern Alpine lakes, spanning from the French Jura to Lake Constance, likely due to the high levels of preservation on waterlogged sites, concentrated in this area (Martin, 2014). Similarly, data from northern Italy is centred around the Po River, particularly south of Lake Garda; although population density was possibly higher in the milder climate of the Po Plains than the southern Alps, waterlogged sites also represent a proportion of this data. Most Alpine data derived from the Prealpine plains and foothills, with limited representation from internal passes or over 1000m (Martin, 2014). Additionally, most sites are interpreted as settlements, including numerous open-air sites in the Valais and Po Plains, and lakeside settlements in the northern Prealps. Cave and rock shelters are more frequent in the karstic networks of Vercors and Liguria and commonly interpreted as sheepfolds, although their Neolithic occupation is poorly understood, with the presence of grains and ceramics overlooked beyond dating (Brochier et al., 1999).

The temporal distribution of data is similarly uneven. During the Early Neolithic, botanical remains are mostly low-altitude, with only four examples over 500m (Pendimoun, La Gilliere, Sion-Tourbillon and Zizers Fridau) while the inner Alps are unrepresented. The Middle Neolithic 1 observes a more even distribution of crop data around the Alps, including at lakesides and in internal valleys, and at increasing altitude. The Middle Neolithic 2 and Late Neolithic are the most abundantly represented periods. During the Middle Neolithic 2, the frequency of sites increased dramatically with the establishment of the lake settlements, however, data remains sporadic beyond this region, although within a greater altitudinal range. This expansion of northern lake settlements continues into the Late Neolithic. However, the increasing frequency of data is not reflected in the western and southern Alps, becoming less numerous during the Late Neolithic, instead having peaked during the Middle Neolithic 1 and 2.

Only a brief overview of Neolithic agricultural economies as understood from existing literature has been presented in this chapter. Detail is limited in the following paragraphs to avoid repetition as an in-depth discussion of western Alpine crop economies is presented in Chapter 4, in which the up-to-date crop macrofossil dataset is analysed.

Most Early Neolithic (5500-4700 BC) assemblages have been recovered from Lindearbandkeramik sites on the northern Alpine foreland and coastal Mediterranean Cardial/Impressa sites (Jacomet, 2007; Martin, 2014; Bouby et al., 2020a). Differences between Linearbandkeramik and Cardial/Impressa crop packages were noted in the literature, in which, although hulled wheats were most important in both spheres, while free-threshing wheats and *Hordeum vulgare* play more significant roles on sites south of the Alps (Jacomet, 2007; Martin, 2014; Bouby et al., 2020a). Martin (2014) described the sporadic recovery of crops such as *Vicia sativa*, *Panicum* sp., and *Secale cereale*, but these are interpreted as wild weeds (Martin, 2014). Although *Linum usitatissimum* and *Papaver somniferum* are reported in southern Italy, *L. usitatissimum* was not recovered around the western Alps, while some cultivation of *P. somniferum* was inferred from the large quantity recovered at Taï (Remoulins) and their infrequent recovery in the northern foreland (Mariotti Lippi, et al., 2018; Bouby et al., 2020a). Bouby et al (2020a) also reported the more frequent recovery of gathered plants, including *Corylus avellana*, and *Quercus* sp., on Prealpine rock shelters than lowland sites in southern France, possibly related to different site functions.

Linearbandkeramik crop husbandry practices from the northern Alpine foreland have been investigated using archaeobotanical remains. Bogaard (2004) inferred from weed data that shifting cultivation – a cycle of cultivation and abandonment – was wasteful in the fertile loess plains, thus likely not used, instead suggesting a regime of spring planting and intensive garden cultivation. Similar methods were later inferred regarding northern Prealpine lake settlements through stable nitrogen isotope analysis on cereals remains, suggesting Middle Neolithic farmers employed manuring and persistent cultivation and maintenance of arable land despite external pressures towards agricultural expansion and hiatuses in settlement occupation (Styring et al., 2016).

Entering the Middle Neolithic 1 (4700-4100 BC), regional differences in core crop package become more subtle. Generally, the prevalence of hulled wheats declined, while free-threshing wheats and *Hordeum vulgare* increased in importance; *Hordeum vulgare* became particularly significant in the Valais and northern Italy (Martin, 2014; Martin et al., 2016). *Pisum sativum* was well-represented across the northern Alps, *Lens culinaris*, *Linum usitatissimum* and *Papaver somniferum* was recovered less frequently (Jacomet, 2007).

The plant economies of the northern Alpine foreland during the Middle Neolithic 2 (4100-3500 BC) are well studied, attributable to the establishment of the lake villages. In this region, free-threshing wheat and six-rowed *Hordeum vulgare* were most popular, particularly *T. durum*, while *T. dicoccum* also remained common (Jacomet, 2007; Martin, 2014). More broadly, core crop packages became increasingly diverse and regionally varied, although *Hordeum vulgare* and *T. dicoccum* were present on almost all Alpine sites; this preference towards hardier crops was hypothesised as suggestive of territorial expansion into the Alps and higher altitude settlement (Martin, 2014; Bouby et al., 2020a). Glume wheats were preferred in small pockets of the northern Alps for unclear reasons, while *T. monococcum* and *T. dicoccum* started to dominate over free-threshing wheats on Chasséen sites in the western Alps after 4000 BC (Beeching et al., 2000; Martin, 2014; et al., 2016). However, understanding of core crop packages is lower resolution in the southwestern Alps due to the more limited dataset. Generally, *Pisum sativum* remained common, while *Lens culinaris* was scarcer

(Jacomet, 2007; Martin, 2014). *Linum usitatissimum* grew in importance on the northern Alpine forelands, while *Papaver somniferum* maintained significance on the Swiss plateau; nevertheless, both crops were absent from internal alpine zones (Martin, 2014).

Regional variability was more apparent during the Late Neolithic (3500-2200 BC). Hulled wheats, particularly *T. dicoccocum*, and *Hordeum vulgare* regained significance across the northern Alps and northern Italy (Jacomet, 2006a; 2009; Martin, 2014). Notably, although free-threshing wheats initially remained important in the northern Prealps, their significance drastically declined around 2700 BC (Jacomet, 2009; Martin, 2014). In southern France, although Prealpine data is limited, *T. monoccocum* continued to gain importance, having begun its resurgence around 4000 BC in the Rhône Valley, re-establishing popularity on open-air sites in the Herault valley by the Late Neolithic (Martin et al., 2016; Bouby et al., 2020b; Jesus et al., 2020). Bouby et al (2020b) noted the increase in glume wheats does not appear correlated with climatic deterioration, however recent research highlighted possible reductions in rainfall in southern France that may have affected *T. nudum* yields (Jesus et al., 2020). *Linum usitatissimum* cultivation boomed across the northern Alpine foreland, likely for textile production, while *Papaver somniferum* representation gradually declined in tandem with the demise of free-threshing wheats with currently unclear cause (Martin, 2014).

A wide variety of wild taxa, reflective of the natural environment or gathered food plants, was also recovered throughout the Neolithic (Jacomet, 2007; Martin 2014). Weed taxa assemblages were fairly regionally and temporally homogenous, excluding a concentration of oil-producing species associated with Middle Neolithic Pfyn settlements including *Descurainia Sophia* and *Brassica rapa* (Martin, 2014). Most frequently represented wild plants include tree nuts such from *Corylus avellana* and *Quercus*, fruits including *Malus sylvestris*, *Pyrus* sp., *Prunus spinosa*, *Rubus fructicosus/ideus, Fragaria vesca* and *Sambucus nigra* (Martin, 2014). *Chenopodium* sp. and *Urtica dioica* were also frequently recovered, although, without contextual evidence for preparation or storage, their consumption is uncertain (Martin, 2014).

Notably, Middle Neolithic cave and rock shelter sites demonstrate some divergence from the plant economies of open-air settlements in the western Alps; these assemblages are comprised of charred material, and usually well-preserved having been sheltered from the elements (Martin, 2014). Located mostly at mid-high altitude and frequently interpreted as seasonally occupied sheepfolds, characterised by compressed dung layers, plant macrofossils from caves have provided insights into early agropastoral economies and the division of the Alpine landscape based on site type and environmental conditions (Argant et al., 1991; Martin, 2014). However, much data derived from early excavations, thus is often poorly reported and semi-quantitative while sampling methodologies are usually unknown. For example, sedimentological data from Chasséen sheepfolds was synthesised by Brochier et al. (1999), however, little information is provided beyond the presence or absence of cereals; subsequently, grains were hypothesised as dietary supplements for livestock, and discussion of their broader cultural or economic significance was neglected. More recent analyses of two sites by Martin (Delhon et al., 2008; Martin, 2014), the rock shelter Les Balmes (Savoie) and cave of Grande Rivoire (Isère) have a provided higher resolution understanding of the role of sheltered sites in Neolithic agropastoralism. The exploitation of wild plant resources in livestock management practices was highlighted, particularly at Grande Rivoire in which two thirds of macrofossils derived from trees and shrubs (Martin et al., 2011). This included the use of young branches for fodder at Grande Rivoire and Les Balmes, including *Quercus*, *Tilia, Alnus,* and *Corylus avellana*, and *Abies* sp. in especially high levels as litter (Martin, 2014). Wild plants were perhaps also used for veterinary purposes at Grande Rivoire; it was suggested *Viscum album* supplemented fodder to encourage lactation in ewes, while the antimicrobial properties of *Taxus baccata* provided sanitary litter (Delhon, et al., 2008; Martin et al., 2011). This suggests an intimate and experienced understanding of the role of the Alpine environment in agropastoral pracitces. However, Martin emphasised that the role of caves is more diverse than previously considered. Cereals were recovered at both sites, but in espeically great quantities at Les Balmes; over 60,000 grains were attributed to the Middle Neolithic 2 to Late Neolithic layers (Martin, 2014). The abundance of cereals may denote a more prolonged occupation of the cave would be expected at a seasonal pastoral site, while the dominance of hardy *T. monoccocum* could indicate their local cultivation at altitude.

2.8. Research at Trou Arnaud

Closely following the initial exploration of Trou Arnaud cave in the 1940s, Neolithic ceramics and grains were discovered in the Galerie des Pots during topographic speleological survey (Daumas & Laudet, 1998). Subsequently, most early studies of Trou Arnaud focused on the ceramic corpus, comprising around 300 complete vessels, eventually forming the foundations of regional ceramic typologies (Vaquer, 1975; Beeching, 1981; Phillips, 1983). This provided a low-resolution chronological narrative, with Middle Neolithic 1 St-Uze tradition vessels denoting occupation since 4700 BC, transitioning later into the main occupational phase in the Chasséen (Daumas & Laudet, 2012).

The first organised excavations were conducted from 1986 to 1990 by Jean-Claude Daumas and Robert Laudet as part of the '*Cultures et milieux des premier Paysans de la Drôme*' project; however, prior unofficial excavations had disturbed stratigraphy from the Galerie du Pots (Daumas & Laudet, 1998). Thus, excavations focused on the detritus cone blocking the ancient entrance to the cave, yielding undisturbed strata containing ceramics, lithics and organic material. Radiocarbon dating of these layers suggests three to four centuries of successive occupation at Trou Arnaud, ranging between c.4460-4040 BC, correlating with the broad ceramic chronology (see Appendix 4).

Paleoenvironmental studies were undertaken to understand the environment surrounding Trou Arnaud. Palynological analysis of one clay vessel revealed a high frequency of ruderal taxa, indicative of nearby pasture and likely of gathered vegetation; this included *Plantago*, *Chenopodiaceae, Polygonaceae*, and cereal *Poaceae* (Daumas & Laudet, 1998). Charcoal was also assessed from numerous layers. Despite a small assemblage, the following picture was suggested: a mountainous vegetation was apparent upon the arrival of the first occupants of Trou Arnaud (*Pinus, Abies, Juniperus*), developing into a collinean (*Quercus, Corylus, Crataegus, Tilia, Ulmus*) and riparian environment (*Corylus, Alnus, Fraxinus, Salix*), with eventual complete disappearance of mountainous species (Daumas & Laudet, 2012). However, charcoal samples cannot be considered representative of the natural vegetation due to the cultural and practical biases in firewood selection.

Two-hundred well-preserved, charred cereal grains from two samples were initially analysed in 1956, identified mainly as *Triticum nudum* alongside *T. spelta* and *T. monoccocum* (Daumas & Laudet, 2012).

Further samples were taken in 1977 and in the 1980s excavations; Erroux suggested *T. monococcum* formed 50% of the assemblage from the Galerie des Pots, *T. dicoccum* represented 36%, *T. nudum* was 13% and *Hordeum vulgare* only 1%, with three examples of *Pisum sativum* also recovered (Daumas & Laudet, 2012). Some confusion between *T. dicoccum* and *T. nudum* was also mentioned due to some atypical morphology, while the total macrofossils assessed was unspecified. Beyond identification, interpretation of the botanical remains was minimal.

The lithic assemblage was typical of the southern Chasséen, including truncated blades and scrapers, with limited retouching; use-wear suggested some use in cereal processing (Daumas & Laudet, 1998). Four polished stone axes, possibly of Piedmont or Ligurian stone, were also collected. Three were finished in the traditions of the MRV, while one was more consistent with later north-western Alpine traditions. This highlights the involvement of the occupants of Trou Arnaud within far-reaching exchange networks across the Alps. A preliminary report also describes the faunal remains; predominantly ovicaprids remains form the assemblage, while the slaughter age was young, supporting interpretations of a birthing sheepfold function (Daumas & Laudet, 2012). Wild animal remains were rare, comprising only chamois and deer, while fragmented remains of three human individuals were recovered but not extensively interpreted.

Ultimately, Daumas and Laudet (2012) remark that the site's function is unclear, although various suggestions are provided to propose Trou Arnaud as multifunctional space. This included its primary function as a refuge, and a lesser role as a sheepfold, based on the abundance of ceramics and grains, unusual for a pastoral site. Further proposals included as a resource gathering base, in which clay was gathered from within the cave, or possibly a religious function, based on hydrological phenomena beyond the Galerie des Pots and the placement of a polished axe within a wall cavity. However, further investigation is certainly necessary to better understand the role of Trou Arnaud throughout the Neolithic.

3. Methodology

A scaled approach to understanding agricultural variation in the Alps was employed through a two-staged methodology. Firstly, a broad narrative on the development of Alpine agriculture was generated through the spatial and temporal analysis of collated archaeobotanical data using visual aids created in ArcGIS Pro and Excel. This was then zoomed in to a case study on the role of mid-altitude caves in the Chasséen agropastoral economy through analysis of archaeobotanical macrofossils from Trou Arnaud. These techniques were well-suited to respond to the research question, enabling an assessment of the Alpine environment's significance in influencing agricultural practices, including the identification of influencing variables such as altitude, site type and archaeological culture, and the generation of a specific example regarding the role of agriculture in the Diois.

3.1. Methods in spatial distribution analysis of Neolithic Alpine crop data

3.1.1. Data collection

Archaeobotanical data in which crop macrofossil data had been semi or fully quantified was collated by Dr Lucie Martin in an Excel spreadsheet for the publication, *Premier Paysans des Alpes* (2014); this dissertation used an updated version of this dataset, adding new quantified crop macrofossil data from individual publications. The study area comprised the Western Alps, longitudinally from contemporary eastern Switzerland to the Rhône Valley in France, and latitudinally from the Po Plains of northern Italy to the loess belt of southern Germany. Data was collated from 88 sites, including new data from Trou Arnaud; the full dataset is presented in Appendix 1.

Data useful for the spatial analysis of crop variation was collected for every site, in which each site represented one unit of analysis. The variables considered per archaeological site included: geographical location using the WGS84 coordinate system, altitude above sea level in metres, period and occupation date range according to dendrochronological or radiocarbon dating, associated archaeological culture, site type, the frequency of various crops, total cereals, and dominant crop type. However, detail on every variable could not be gathered for all sites, especially from older reports in which botanical reporting is often limited. Some sites are represented by multiple entries presenting different phases, when more detailed chronological data could be gathered. The frequency of specific crops is recorded hierarchically, dependent on the specificity of data available, in which numerical quantity is preferred, then percentage of assemblage, then semi-quantitative abundance. Regarding semi-quantitative values, crops are represented as 'present' usually as very limited or individual examples, as 'common' in more representative numbers, or 'abundant' when found in great quantities of several hundred remains. The hierarchical presentation of data allowed the most precise representation of the crop economy to be generated within the limitations of the dataset; although the inclusion of semi-quantitative data limited accuracy, it maximised the amount of data available for use. In cases where crops were recorded only as present or absent, or remains were identified only as *Cerealia*, a dominant crop type could not be discerned. Furthermore, the WGS84 coordinates used are not always precise; many reports do not disclose the exact location of sites. However, an approximate area, at least to the nearest contemporary settlement, has been identified for every entry; this is adequate for broad-scale distribution mapping.

3.1.2. Mapping and pattern analyses in ArcGIS Pro and Excel

Figures were produced in ArcGIS Pro, overlaying site distributions and associated crop data onto a topographical representation of the Alpine landscape. Default World Hillshade and World Topographic base-maps were used in ArcGIS Pro software by Esri, while vector files from Natural Earth were downloaded, representing contemporary country outlines, major lakes, and rivers. This map was cropped to the study area, providing a base representation of the topography of the Alpine region. However, it must be considered that the base-map depicts the present-day Alpine landscape. This has been highly modified over the past millennia through industrialisation, farming, mining, quarrying, and climate change, alongside glacial mobility, a variable factor specific to Alpine studies. Therefore, maps are not wholly representative of the environment experienced by Neolithic societies. As this dissertation took a generalised view of the landscape and an understanding of Alpine paleoenvironmental history was developed prior to analyses, these differences do not greatly inhibit the functionality of the figures.

XY data from the Excel spreadsheet of sites with crop data was exported into ArcGIS Pro as a CSV file. Subsequently, sites were plotted across the study area. The symbology of this data was manipulated to create point distribution maps based on the variable criteria, illustrating spatial patterning in Alpine crop data across the entire study area and in more focused regions. For example, the dominance of certain crop types in relation to region or site type was explored. These maps were used to interpret the dataset with consideration towards the research question and objectives of the dissertation, highlighting changes in core crop packages as the Alps were populated, including the adaptation of cultural crop packages in response to Alpine environmental conditions and climatic change. Functions in Excel and Powerpoint were also used to create charts and graphs to investigate proportional differences in crops between sites or other variable factors, complimenting mapped data.

3.2. The case study of Trou Arnaud: techniques in archaeobotanical analysis

3.2.1. Sampling and processing of charred material

A limiting factor in this work is the minimal detail provided in the published site reports regarding the sediment sampling strategy at Trou Arnaud, employed by Daumas and Laudet during the 1986-1990 excavations and in previous unstructured collections in the Galerie des Pots (Daumas & Laudet 1998; 2012). However, it is known two samples of approximately 200 seeds were collected from the Galerie des Pots in 1956 by Marcel Coquillat of the Société Linnéenne de Lyon, with a further 270cm^3 collected in 1977 by Arséne Héritier. It can be safely assumed these were collected according to judgement sampling, limiting interpretations into site organisation as deposits with less concentrated remains were likely not collected. Furthermore, during the 1956 excavations, grains were perhaps collected primarily through hand picking upon observation by excavators; thus, these assemblages are unrepresentative, overlooking smaller macrofossils and weed seeds. Extensive disturbance of the stratigraphic integrity of Trou Arnaud was noted, resulting from these early disorganised excavations (Daumas & Laudet, 1998).

The first systematic sampling was undertaken by Daumas and Laudet from 1986-1990, providing further sampling of the Galerie des Pots and of the detrital cone blocking the past entrance to the cave system, the focus of the excavation (Daumas & Laudet, 1998; 2012). However, details regarding the number and volume of sediment sampled, any subsampling undertaken, flotation techniques, sieving mesh sizes and storage of processed material have not been published. These factors affect the preservation of plant remains and representativeness of the assemblage on a site-wide scale. Methodologies underpinning the selection of areas for sampling are also unspecified. It is likely sampling was somewhat systematic due to the broad range of contexts from which macrofossils have been recovered. However, certain areas, particularly hearths, appear comprehensively sampled, while no remains are present for many areas (see Appendix 5 for site plans). It is likely the identified assemblage has been biased by the sampling strategies and may not accurately reflect the character of the whole site. Consequently, interpretations of inter-site organisation and chronology are tentative to avoid the overinterpretation of an essentially incomplete dataset.

3.2.2. Identification protocol

Plant macrofossils were inspected one sample at a time using a GX XTL3T101 low-powered stereomicroscope at 100x magnification. Small portions of the sample were poured into a glass petri dish, and individual material was systematically passed under the microscope for inspection using a fine pair of steel tweezers, then subsequently identified and counted. Cereal grains and seeds were examined, identified, and categorised to at least family level, then if possible, according to genus and species, and recorded following the *International Code of Nomenclature for algae, fungi, and plants* (Turland et al., 2018). This was possible in most cases of cultivated flora, allowed by mostly satisfactory level of preservation by charring, however more fragile, smaller or weed seeds are infrequent and poorly preserved. Regarding examples where identification is uncertain, recordings follow standard nomenclature in being categorised as 'Certain genus cf. uncertain species' or in a separate category comprising more than one potential candidate. For example, numerous grains appear morphologically indistinct between *Triticum dicoccum* and *Triticum aestivum/durum/turdigum* (*T. nudum*); therefore, these were recorded as '*T. dicoccum/T. nudum'.*

Plant material, including seeds, chaff, and other charred remains, were identified using an eliminative method whereby potential candidates were ruled out according to morphological characteristics, including forms and size ratios in plan, profile and section, surface characteristics, diagnostic areas of seeds such as the embryo, and to a degree, overall size. As opposed to simple matching, this method mitigates the effect of biases towards preconceived identifications based on the prior published analyses, which may lead to mistaken identities. Identification was assisted by reference texts (Hillman et al., 1996; Martin, 2000; Jacomet, 2006b; Neef et al., 2012; Cappers & Bekker, 2013), and one to one comparison with charred and uncharred specimens from the modern seed reference collection at the University of York. A catalogue of taxa, including identification criteria for identified flora is described in Appendix 7.

3.2.3. Quantification

The number of individual specimens per taxon were counted according to each sample and entered into an Excel spreadsheet to allow manipulation and exploration of data through descriptive relational statistics. These were categorised into groups of crops, arable and ruderal weeds, and wild taxa. Quantitative totals and the proportional percentages of each taxon was calculated for each sample and site-wide. The full spreadsheet of macrofossil data from Trou-Arnaud is presented in Appendix 6.

Whole, or near complete, specimens were counted. Fragmentary cereal remains were quantified to calculate a Minimum Number of Individuals (MNI) according to the methodology proposed by Antolin & Buxo (2011) in which the most represented type of transverse and longitudinal fragments was counted and added to the total for each taxon (see figure 4). This provides a higher and more representative reflection of the original assemblage than the method proposed by Jones (1990), in which an MNI is generated through the quantification of one countable feature, such as grain embryo end or hilum. The accurate calculation of the number and character of fragmented grains also provides a greater understanding of the effects of taphonomic process upon the state of preservation. In the case of non-cereal remains, fragments were counted and divided by four for larger fragments, in which over one third of the individual is represented, or by ten for smaller fragments of up to one third of an individual. Macrofossils were of generally good levels of preservation, mostly intact with some erosion, although all levels are represented between intact to over-degraded. The level of fragmentation for each context, taxon, and in total, was quantified by calculating the percentage of remains that are represented by whole individuals, against individuals quantified via a MNI from fragmentary remains.

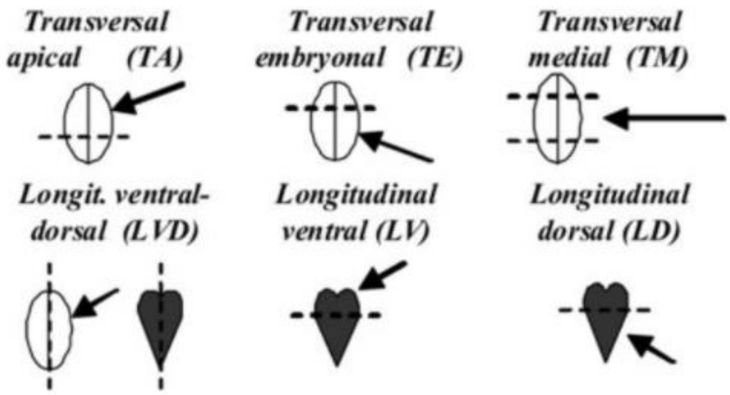


FIGURE 4. TYPES OF COUNTABLE CARYOPSES FRAGMENTS (ANTOLIN & BUXO, 2011).

3.2.4. Statistical analysis of plant data

Graphical and tabulated representations of the quantified botanical material have been created in Excel to display basic relational statistical data. Sample and site-wide quantifications of taxa were compared in tables to explore the proportions of different crop type, chaff-grain rich ratios, and weeds representative of surrounding landscape. These have been plotted onto pie and bar charts to display differences in the proportions of crops recovered from different samples and stratigraphic layers to enable analysis of intra-site spatial patterning and chronological variation in the botanical assemblage. Through this, early agricultural practices in the Diois have been explored, including changes in the significance of certain crop types over time, the cultivation of crops best suited to Prealpine environmental conditions, and the role of Trou Arnaud within the Chasséen agropastoral economy.

4. Understanding the implications of Neolithic crop variation across the Alpine Arc

The results of the spatial analysis regarding Alpine crop variation are presented here and illustrated through a series of maps. Agricultural adaptations made by Neolithic societies while populating marginal environments are discussed to explore themes, including the marginality of Alpine plant economies, and the environmental and climatological motivations behind crop packages. It should be noted that climate fluctuations, while frequent, were moderate, relating more to changes in seasonality than extreme events.

This synthesis builds upon the work by Martin (2014) and other collations of botanical data (Jacomet, 2007; Bouby et al., 2020a; 2020b; Jesus et al., 2020) from the Alpine landscape with a specific focus upon variety across Alpine cereal crop packages. Subsequently, new perspectives were generated, and the accuracy of earlier datasets was supported.

Figures relating to crop distribution across altitudinal zones and non-cereal crops are presented in Appendices 2 and 3 respectively.

4.1. Accuracy of the dataset and preservation biases

Sites with botanical data are unevenly distributed around the Alps, both spatially and across the Neolithic period, primarily attributable to biases in preservation. Most sites are clustered around the northern Prealpine Lakes of the Swiss Plateau and southern Germany. Although some material is charred, most data is represented by waterlogged macrofossils. These are often well-preserved in an unaltered state; thus, identifications are robust or identified to a higher specificity. Comparatively, charred remains are subject to more distortion during burning and erosion through post-depositional disturbance (Boardman & Jones, 1990; Jacomet, 2012). Consequently, waterlogged sites appear more species-rich, particularly in undomesticated flora, than many dry sites; thus, agricultural practices, such as fallowing strategy, are better understood. Additionally, oil crop seeds, such as *Linum usitatissimum* and *Papaver somniferum*, which rarely survive charring, are better preserved, hence their scarce representation beyond the Lake settlements. Nevertheless, the diversity of cereal and pulse varieties is similar across the Alpine landscape; therefore, differences in packages relate to the proportions of specific crops as opposed to a distinct spectrum of cultivated plants. Consequently, a higher-resolution understanding of northern Prealpine plant economies has been generated, in which sites are more representative due to the higher volumes of remains. This contrasts with sites in northern Italy and the internal Alpine valleys in which few grains were preserved; therefore dominant crop types cannot be consistently established. These limitations are highlighted in following discussions.

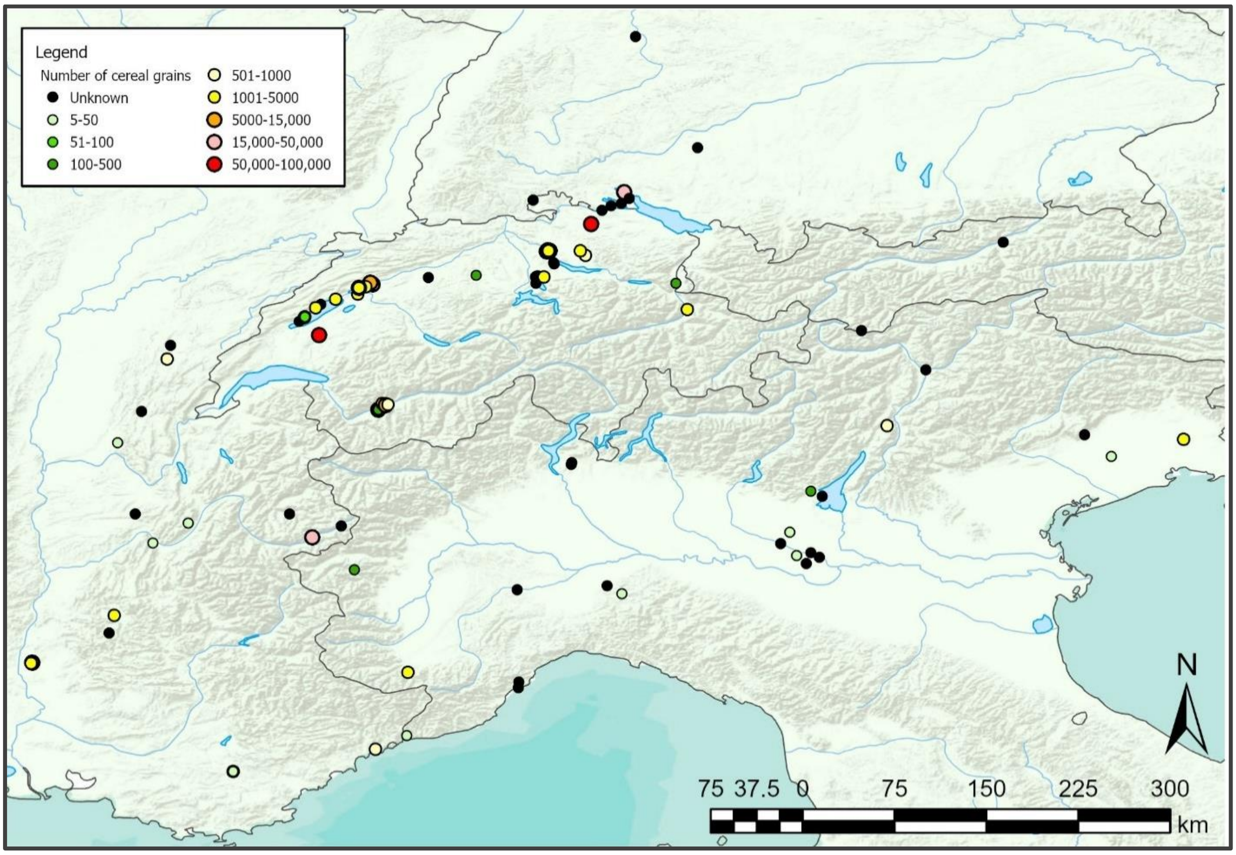


FIGURE 5. TOTAL NUMBER OF CEREAL GRAINS AT ALPINE SITES, IN WHICH TOTAL GRAINS ARE GENERALLY HIGHER IN THE NORTHERN PREALPS AND SMALLER OR UNKNOWN TO THE SOUTH.

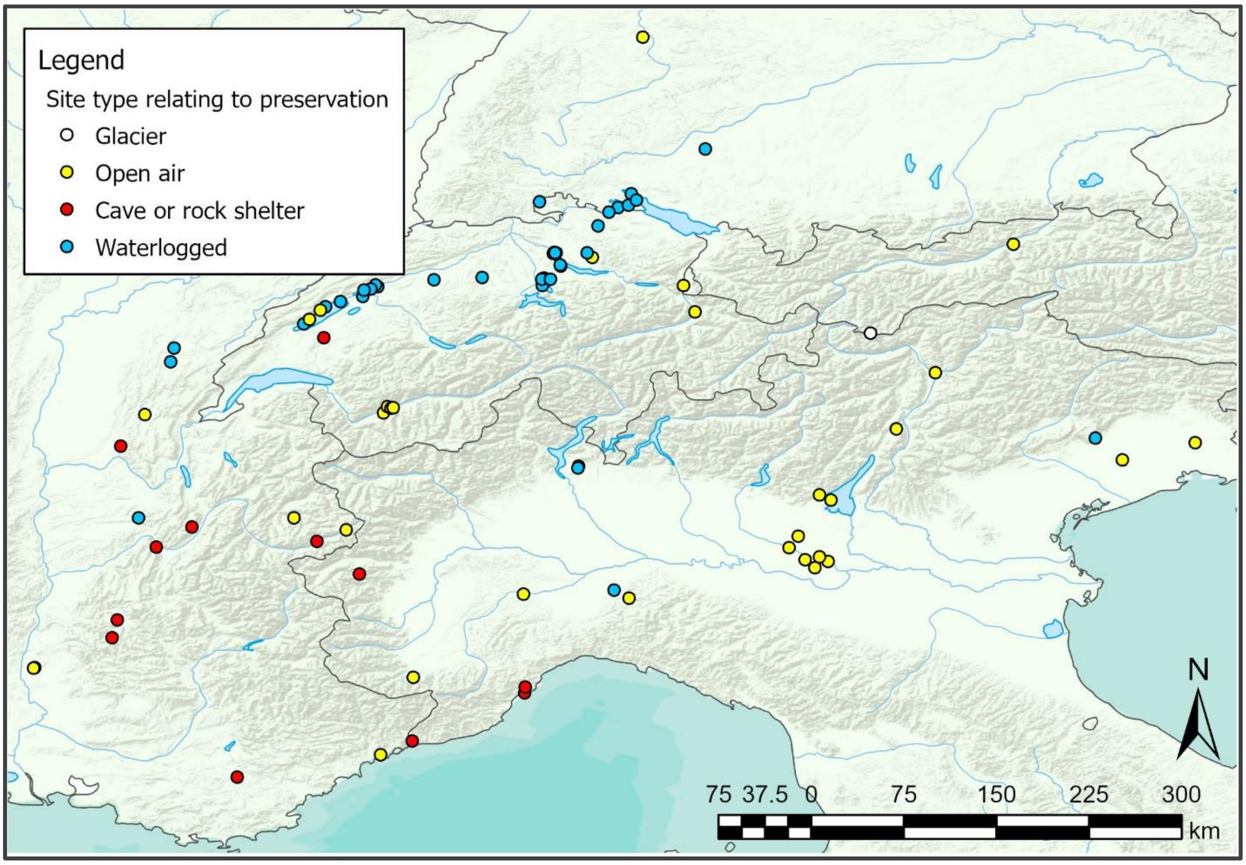


FIGURE 6. PRESERVATION TYPE OF ALPINE BOTANICAL REMAINS; WATERLOGGED REMAINS ARE CLUSTERED AROUND THE NORTHERN PREALPINE LAKES, CAVES AND ROCKSHELTERS OCCUR IN THE WESTERN ALPS, AND OPEN AIR SITES DOMINATE NORTHERN ITALY.

Much data is represented by cave and rock shelter sites, particularly in the western Alps during the Middle Neolithic. These often provide dry preservation conditions, with sediments protected from weather-induced erosion. Furthermore, limited flora grows in cave environments, thus most plant remains are deposited by humans or animals (Paz, 2005). Nevertheless, many Neolithic cave sites functioned as sheepfolds, therefore these layers were subjected to more mechanical stress and can present more eroded or fragmented remains than expected in sheltered environments. Macrofossil preservation can further vary due to the nature of occupation; sites with domestic functions provided more opportunities for carbonisation, for instance through the drying of crops or culinary accidents, while shorter occupied pastoral camps generally produce few remains, likely carried by shepherds to feed themselves. Some open-air sites, particularly in northern Italy, produce extremely scarce remains, possibly resulting from the aggressive taphonomic processes on exposed sites, especially in areas with high hydrological activity like the Rhône Valley and Po Plains (Brochier, 1997).

Representativeness is also affected by the quantitative approaches adopted by researchers. Much data is semi-quantitative, recording remains as present/absent or a qualitative measure of abundancy (present, common, abundant). This results in the underrepresentation of dominant crops and overrepresentation of those recovered in small or individual quantities. To deal with this problem, the data here has been hierarchically collated (in numerical quantity, in percentage, then in non-numerical abundance) according to the data available. Certain regions have provided less quantitative data, either due to the restricted recording practices or limited accessibility to data, particularly on sites excavated during the 20th century. Much data from northern Italy is semi-quantitative; this problem is exacerbated by the limited sampling of northern Italian sites, mainly deriving from small-scale excavations or judgement sampling (Rottoli & Castiglioni, 2008). These limitations were considered in interpreting this dataset.

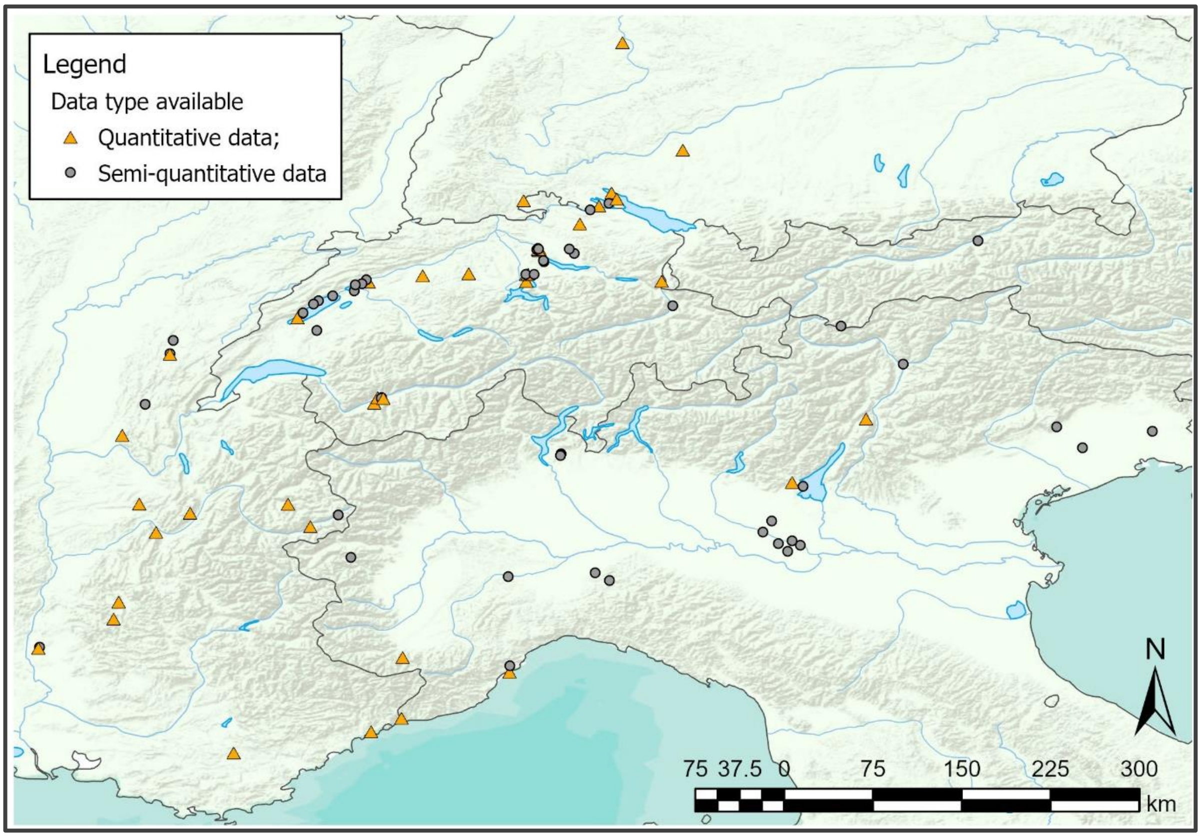


FIGURE 7. TYPE OF DATA AVAILABLE FOR ALPINE PLANT REMAINS; FULLY QUANTIFIED DATA IS UNCOMMON IN NORTHERN ITALY AND AROUND LAKES NEUCHÂTEL AND BIENNE.

4.2. Chronology and cultural considerations in farming practices

The composition and changes in Neolithic crop packages across the Alpine landscape are described in the following section. These are outlined and cultural, socioeconomic, or environmental motivations for arable practices are discussed. A focused discussion of the potential for higher altitude cultivation is presented in Section 4.3.

FIGURE 8. KEY FOR THE PIE CHARTS IN MAPS IN CHAPTER 4.

Early Neolithic (5500-4700 BC)

There are clear differences in crop choice north of the Alps, following the Neolithisation routes of the Linearbandkeramik culture, to those linked to the Mediterranean stream. Even so, some homogenisation is apparent towards the Early-Middle Neolithic transition, implying the crossing of high-altitude ranges by early farmers (Schwörer et al., 2015; Hafner & Schwörer, 2017).

Contrasting with later periods, almost all Prealpine Early Neolithic plant data comes from sites in the western and southern Prealps, with only Zizers Freidau (Grisons) representing the Linearbandkeramik package. This is unsurprising, considering the earliest Danubian groups spread primarily along loess soils in northern Europe, while the maritime dispersal of Mediterranean farmers necessitated adaptation to the cultivation of poorer soils (Jacomet, 2007). Furthermore, this reinforces interpretations of a firstly Mediterranean exploration of the Alps by farmers via the Rhône Valley and Alpine passes between the Po basin and Swiss Plateau. Sites are mostly low-altitude, all below 700m elevation and mostly below 500m, consistent with the Alps being explored although not yet permanently settled (Gallay, 1990). Consequently, mountain cultivation was sparse or non-existent.

Crop remains from Linearbandkeramik sites are scarce on the Swiss Plateau; most botanical data was recovered from beyond the Alpine landscape on the loess band spanning Lower Bavaria and Neckar. However, data from 20 sites collated by Jacomet (2007) provides a good understanding of the crop package bordering the northern Alpine foreland, identifying *T. monococcum* and *T. dicoccum* as the dominant crops, while other cereals are rare. *Hordeum vulgare* is present on only nine sites, generally represented by under ten grains, and *T. nudum* was recovered only twice. Zizers Freidau was less characteristic of the Linearbandkeramik package, although this may allude to Mediterranean influences north of the Alps towards the Middle Neolithic. This was materially attested at Grande Rivoire between 5500-5200 BC by the recovery of southern French Cardial lithics and Sardinian obsidian, suggesting an exchange network spanning to the Tyrrhenian coast (Nicod et al., 2019). By 4800 BC, the arable corpus at Zizers Freidau was dominated by *Hordeum vulgare*, while *T. dicoccum* is the most common wheat with discreet amounts of *T. monococcum* and *T. nudum*. Although the preference towards glume wheats is characteristic of earlier Linearbandkeramik sites, the trace of *T. nudum* and dominance of *Hordeum vulgare* may reflect southern influences.

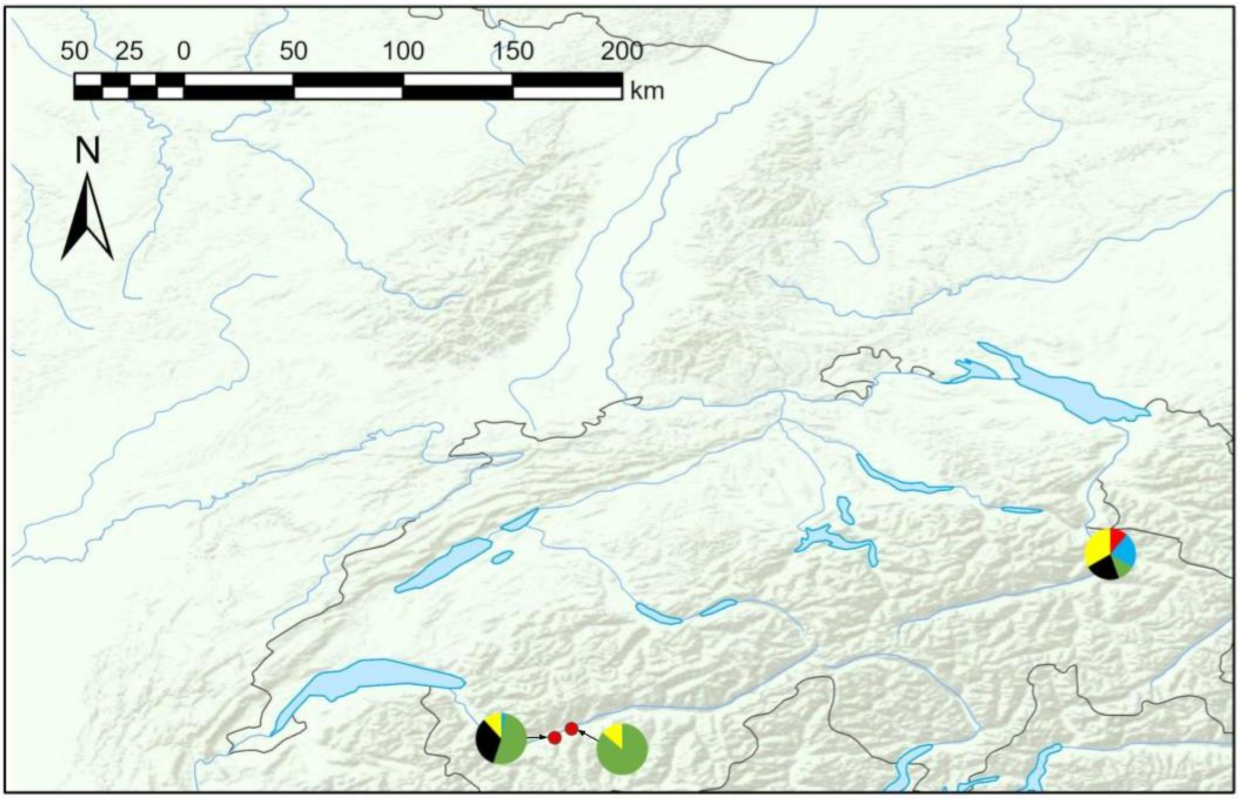


FIGURE 9. EARLY NEOLITHIC SITES IN THE NORTHERN PREALPS; T. NUDUM DOMINATES VALAISIAN SITES, CONTRASTING WITH GLUME WHEATS ON THE PLATEAU.

Conversely, crop assemblages south of the Alps commonly comprise *T. nudum* and *Hordeum vulgare* alongside *T. monococcum* and *T. dicoccum* as the core crops. Three main packages are discernible: those associated with the Impressa Culture observable from 5850 BC around Lombardy and Alpes-Maritimes, and those of the Cardial/Epicardial, emerging in Languedoc, and the Vho/Fiorano cultures of the Po Plains, both from around 5400 BC (Bouby et al., 2020a). All Early Neolithic data from northern Italy is semi-quantitative; thus the relative importance of specific crops per site is difficult to assess, while assemblages are rarely representative and not robustly dated, particularly in the Oglio river and Lake Varese areas (Starnini, 2018).

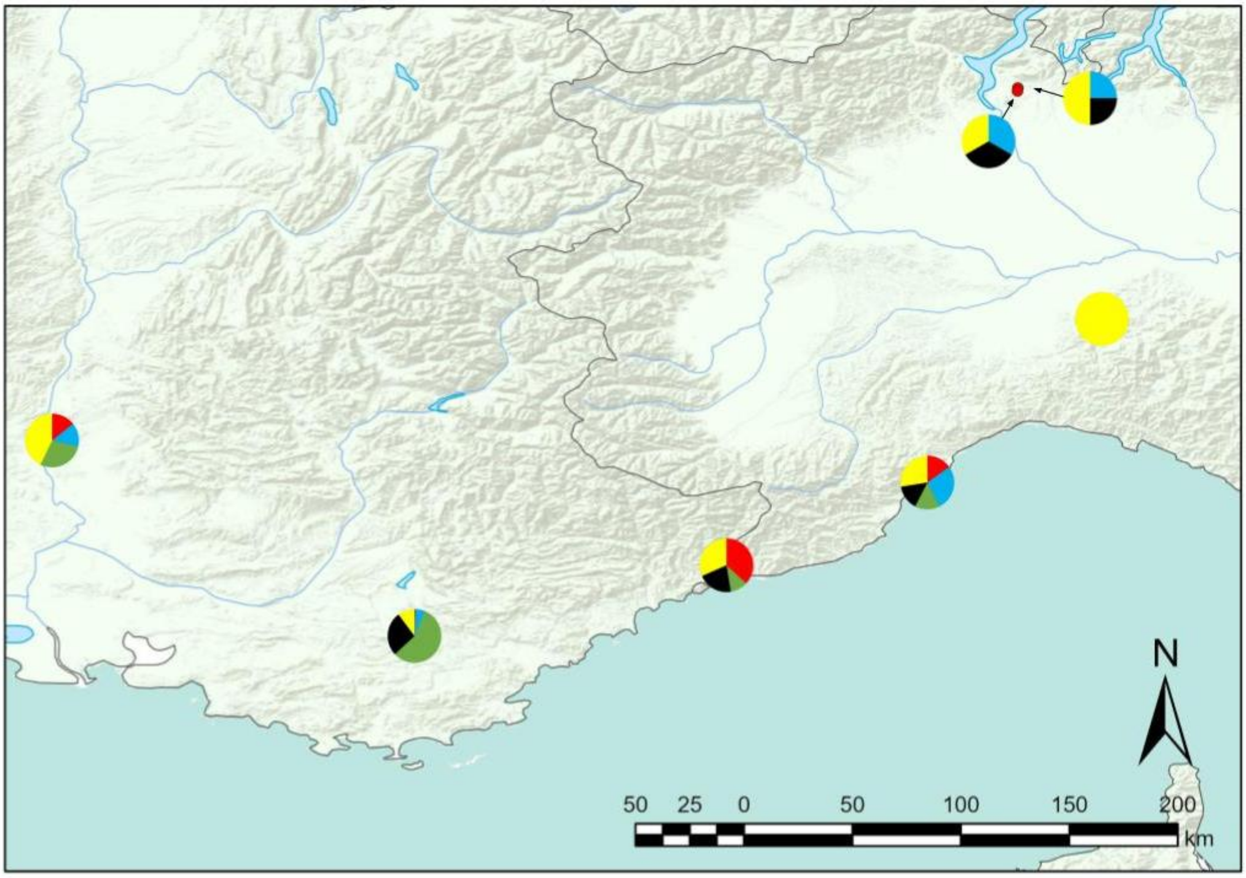


FIGURE 10. EARLY NEOLITHIC SITES IN THE WESTERN ALPS; GLUME WHEATS ARE MOST COMMON ON THE EARLIEST SITES, WHILE T. NUDUM IS POPULAR IN THE RHÔNE VALLEY DURING THE LATTER HALF OF THE PERIOD.

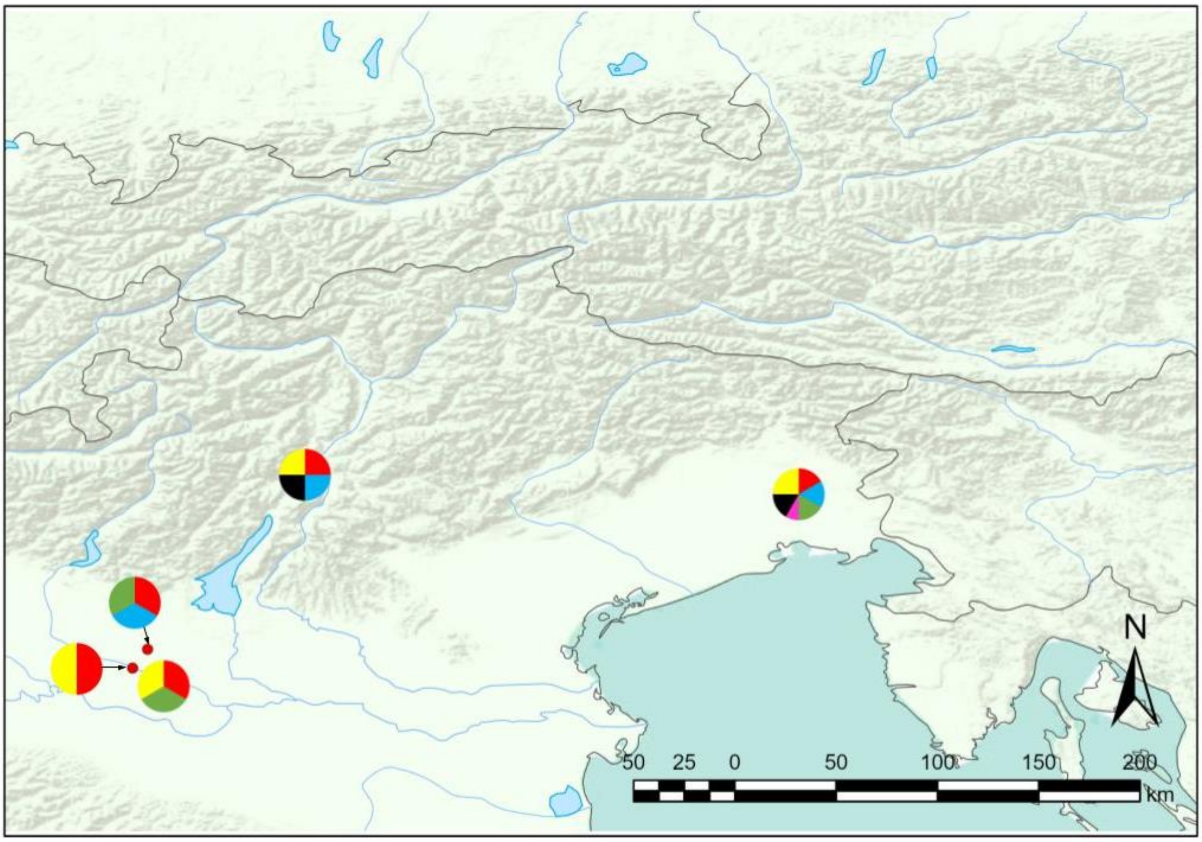


FIGURE 11. EARLY NEOLITHIC SITES IN THE CENTRAL ALPS AND PREALPS; SITES ARE HETEROGENOUS BUT T. MONOCOCCUM AND HORDEUM VULGARE ARE MOST COMMON.

Groups of the Impressa culture represent the first Prealpine farmers, occurring on coastal sites. The cereal assemblages at Pizza di Bodio (Lombardy), Arene Candide (Liguria) and Pendimoun (Alpes-Maritimes) include a dominance of glume wheats – *T. dicoccum* in the cases of Pizzo di Bodio and Arene Candide and *T. monococcum* at Pendimoun – alongside some *Hordeum vulgare* and *T. nudum* in trace quantities. This is typical of the Impressa crop parcel and differs little from the first Impressa sites on the western Italian peninsula, although the choice of hardier glume wheats perhaps aided adaptation as groups explored inland from the northern Mediterranean (Bouby et al., 2020a).

The later Vho/Fiorano package emerging around the Po Plains is broadly similar, but the importance of *Hordeum vulgare* is more significant, while glume wheats, especially *T. monococcum,* retain their significance; *T. nudum* is also present, although mainly on sites with small sample sizes. *T. monococcum* became especially common in northeastern Italy, present on all sites in eastern Lombardy, Trentino-Alto Adige, and Friuli-Venezia-Giuli, although its importance diminishes in the western half of the Po Plains. *T. dicoccum* is frequent in lower numbers, present on half the Vho/Fiorano sites. While *T. nudum* occurs on half the sites, it is represented within minimal sample sizes along the Oglio river - only five and seven total cereal grains were assessed at Vho Campo Ceresole and Isorella respectively. Nevertheless, it was common at the representative site of Sammardenchia (Fruili-Venezia-Giulia), suggesting *T. nudum* was regionally cultivated but less extensively than glume wheats. *Hordeum vulgare* is very common, present at nearly all sites, excluding the unrepresentative site of Isorella, and is the only crop present at Cecima; its dominance at Sammardenchia further highlights its regional significance. *T. spelta* appears in small numbers at

Sammardenchia, but is rarely recovered elsewhere in the Alps, thus possibly represents a weed of cereal crops (Martin, 2014).

One notable cluster of sites occurs around Lake Varese, with a distinctive crop package of solely *T. dicoccum* and *Hordeum vulgare*, persisting over the Early Neolithic at Pizzo di Bodio and Isolino. This regional reduction in crop diversity coincides with the limits of the Gruppo dell Isolino archaeological subculture, derived from Impressa and Vho/Fiorano influences (Baioni et al., 2005). Although Varese is on average cooler than the surrounding Lombardian prealpine villages, the broader popularity of glume wheats suggests a cultural preference for *T. dicoccum* is more likely than environmental influences, implicating the development of distinct agricultural characteristics between the Alpine foothills and Po Plains.

Contemporaneously on the western edge of the Alps, the Cardial package contrasts with the Vho/Fiorano parcel, comprising mostly *T. nudum* and *Hordeum vulgare*, with smaller amounts of glume wheats. In the Rhône Valley, *T. nudum* was the most popular wheat variety on Cardial sites. It forms the dominant crop at Fontbregoua (Var), and the primary wheat variety at La Valladas (Drôme), reflecting increasing popularity during the Early Neolithic. *Hordeum vulgare* was an extremely significant crop; while underrepresented at La Valladas by semi-quantitative data, Martin (2014) notes *Hordeum vulgare* comprises 95% of cereals. Mirroring the situation in Iberia of a *T. nudum-Hordeum vulgare* package, particularly following the emergence of the Epicardial in Provence, the western Prealps were clearly associated with Western cultural groups (Bouby et al., 2020a).

Notably, the divide between the Cardial and Vho/Fiorano cultures lies roughly around the Alps. However, as Early Neolithic Mediterranean cultures primarily underwent a maritime dispersal, this perhaps reflects western Epicardial influences in the Rhône Valley rather than a separation influenced by Alpine topography. Reinforcing this, the occupation of the most representative site, La Valladas, between 5030-4800 BC, coincides with the northwards spread of the Epicardial along the Rhône (Bouby et al., 2020a). Meanwhile, Impressa and Vho/Fiorano groups were influenced by cultures on the Adriatic coast and southern Italy, illustrated by material cultural differences with groups in southern France regarding burin use-wear and ceramic typologies (Starnini, 2018).

The internal Alpine valleys are represented only by two sites, both in the Valais; Tourbillon (Sion) and La Gilliere, dated broadly to 4900 BC. Crops were likely cultivated in the valley bottoms, dominated by *T. nudum*, with *Hordeum vulgare* also well-represented and discreet amounts of *T. dicoccum*. Their links to Mediterranean populations via the Rhône Valley and Po Plains are implied by this consistency with Cardial crop packages, while ceramics at Tourbillon share characteristics with the Gruppo dell Isolino (Martin, 2015). Nevertheless, groups in the Valais continuously operate with an independent crop package throughout the Neolithic. The marginality of inner Alpine Upper Rhône Valley groups was reflected in both crops and material culture; the persistence of Mesolithic lithic technologies into the Middle Neolithic at Gardon (Ain) suggests limited association with surrounding Neolithic groups (Perrin, 2003).

Beyond the cereal data, evidence for pulse cultivation is rare. *Pisum sativum* was recovered from three sites, at Zizers Freidau (Grisons), La Valladas (Drôme), and Sammardenchia (Friuli-Venezia-Giulia), although limited remains identified as *Vicia* sp. from Arene Candide (Liguria) suggests some pulse cultivation. Jacomet (2007) noted peas were an important element of the Linearbandkeramik plant economy, present at 12 of 20 sites. *Lens culinaris* was much rarer, recorded in small quantities at Sammardenchia and Arene Candide, and on 6 of the 20 Linearbandkeramik sites (Jacomet, 2007). However, poor preservation has likely contributed to the underrepresentation of pulses; *Pisum* may sometimes lose identifying characteristics, including the hilum, during charring; thus, their rarity is unsurprising considering the similarly poor preservation of southern Early Neolithic cereals (Fuller & Karoune, 2006). Even so, its broad geographical recovery implies cultivation in both Linearbandkeramik and Mediterranean packages, albeit less frequently than cereals. Interestingly, Bouby (2020a) notes *Pisum sativum* is only recovered prior to 5000 BC in the Early Cardial phase. Although corroborated by this dataset, further sampling is required to determine whether pulse cultivation genuinely declined in the Recent Cardial, or if preservation biases misconstrued their importance. Similarly, the cultivation of *Papaver somniferum* was limited to the Valais and on Zizers Freidau, while *Linum usitatissimum* is absent in the Early Neolithic. Although, this is partly due to their limited preservation on dry sites, becoming more common following the settlement of lakeside sites.

Overall, the Early Neolithic Alpine plant economy reflects the Linearbandkeramik and Mediterranean routes of Neolithisation, demonstrating differences between northern and southern packages. A specifically Alpine character had not yet developed, as crop packages rarely diverged from the wider picture in western Europe. Crop choice was mostly affected by cultural preference over environmental motivations, with some subgroups emerging in environmentally marginal regions such as the Valais and Italian Prealps.

Middle Neolithic 1 (4700-4100 BC)

The Middle Neolithic 1 is characterised by the increased settlement of mid-high altitudes and some early settlement of the Prealpine lakes centred around Neuchâtel, Zug and Zurich. Climatically the most stable period during the Neolithic, this is unsurprising, as mountain conditions were warmer and less humid (Magny, 2004). Material culture and botanical evidence allude to greater contact between populations on northern and southern sides of the Alps, in which many parts of the Alps are incorporated into the broader Mediterranean cultural sphere, while subgroups become distinct in marginal environments. This highlights the existence of well-established and wide-ranging exchange networks involving the traversing of high-altitude ranges.

Crop packages around the northern Alps followed generally similar trends, with some regional nuances. Tetraploid varieties of *T. nudum* became most popular alongside comparable or smaller numbers of *T. monococcum* and *T. dicoccum*. This corresponds with a period of climatic stability (5250-4250 BC) comprising higher temperatures and lower precipitation, creating ideal cultivation conditions for *T. nudum*, well-adapted to aridity and temperate climates (Magny, 2004). Meanwhile, the Neckar and Bavaria regions north of the Alps retained a preference towards glume wheats, distinct from the Alpine crop packages (Jacomet, 2007). Indicating an increasing Mediterranean influence across the Alpine landscape, the popularity of *T. nudum* mirrors its rise in Chasséen and St Uze crop packages across southern France and the Rhône Valley; influences from the west are supported by the preceding persistent recovery of tetraploid wheats in Iberia during the Early to Middle Neolithic (Martin, 2016; Jesus et al., 2020). Influences may also stem from the Michelsberg culture that spanned from the Paris basin to Eastern Rhine, in which hexaploid wheats dominated alongside *T. dicoccum*, comparable to crops at Kleinerhafner (Zurich) (Martin, 2016). Nevertheless, agricultural technologies employed in the Alps mirror those in the Mediterranean, distinct from those of northern and Central Europe. Adaptation of Mediterranean technologies was reflected at Egolzwil (Lucerne), where two-stage reaping knives, originating in Cardial Provence during the 6th millennium BC, were adapted for the high yields from Egolzwil cereal fields, contrasting with curved sickle technologies in the German loess belt (Gibaja et al., 2017).

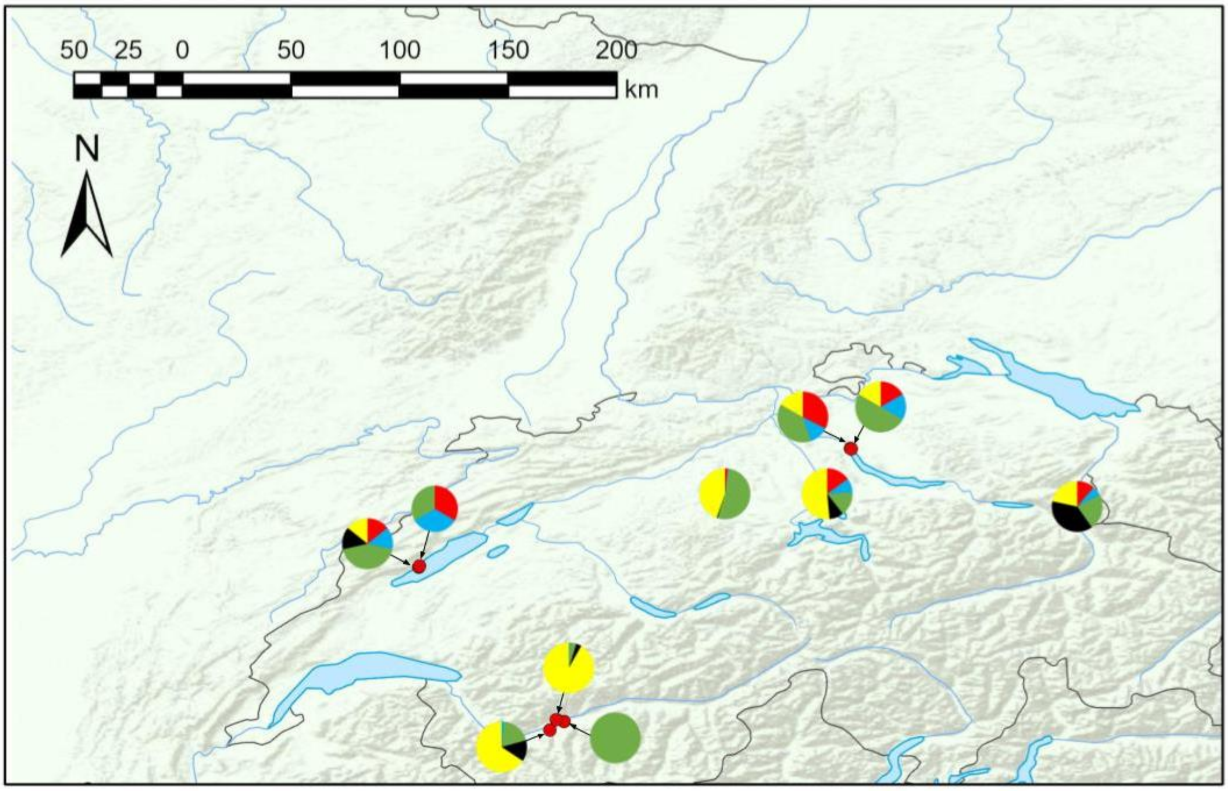


FIGURE 12. MIDDLE NEOLITHIC 1 SITES IN THE NORTHERN PREALPS, INCLUDING THE FIRST LAKESIDE SETTLEMENTS; T. NUDUM AND HORDEUM VULGARE IS COMMON, ESPECIALLY IN THE VALAIS.

Hordeum vulgare is common in the northern prealps, but usually secondary to *T. nudum*, although at Cham-Eslen the sample comprised only 33 grains. *Hordeum vulgare* also plays a diminished role on sites associated with the Egolzwil culture on the western bank of Lake Zurich, and on the Epi-Rossen site of Pfafersbuel (Saint Gall); possessing similar climates to Egolzwil sites around Zug, this likely related to socioeconomic or cultural motivations rather than an adaptation to ecological conditions. Additionally, a minimal popularity of *Hordeum vulgare* around Lake Neuchâtel was perhaps linked to site function. Derriere La Croix and Vaumarcus-Champs Devants were part of a megalithic complex associated with the Early Cortaillod culture centred around Neuchâtel (Wuthrich, 2003). While Late Neolithic evidence of barley breads have been discovered in Zurich, *Hordeum vulgare* may have been seen as a low-status crop, hence its underrepresentation at sites in which ritual consumption was likely represented alongside domestic waste (Heiss et al., 2017). Noted as less useful for baking than *Triticum sp*., producing coarse, dense, and unstable dough when using modern varieties, it is more suited to stews, porridges, or flatbreads (Niffenegger, 1964; Kreuz 2020). This may indicate a crop hierarchy, similarly observed in 19th century southwestern Germany in which barley bread dominated in economically turbulent times (Korber-Grohne, 1987).

Although the components of the Valaisian crop package persist from the Early Neolithic, *Hordeum vulgare* overtakes *T. nudum* in popularity at La Gilliere (4700-4450 BC) and Saviese La Soie (4680-4250 BC), while *T. dicoccum* remains discreet. At Les Saturnales, Av. Ritz, only *T. nudum* is recovered, however, this is dated to the Middle Neolithic 1-2 transition (4250-3750 BC); the reason for this difference is uncertain. Despite sharing ceramic material consistent with Cortaillod traditions at Neuchâtel, this scarcity of glume wheats is unique in the Alpine landscape, notwithstanding the St Uze cave of Gardon yielding only 6 grains. This suggests farmers in the Valais formulated agricultural strategies independently from surrounding groups, rather than passively adopting approaches developed by neighbouring cultures.

In the southern and western Alps, a different character is demonstrated in crop packages either side of the Alps. The Rhône Valley is represented mostly by caves and rock shelters, with only Les Moulins (Drôme) an open-air settlement. *T. monococcum*, *Hordeum vulgare* and *T. nudum* were most common, alongside limited *T. dicoccum*. The popularity *of T. monococcum* is notable, occurring on every site but Gardon, while *T. nudum* also appears on all sites. The presence of *T. dicoccum* is confined to the Middle and Southern Rhône Valley, however, the northern sites yielded especially small sample sizes (Gardon, Aulp du Seuil, and Grande Rivoire). Even so, Martin (2016) suggests an increase in *T. dicoccum* can be traced to Iberia around 4500 BC, its exploitation increasing during the Middle Neolithic; thus southern sites exhibit these influences more intensely. *Hordeum vulgare* is usually significant, present on all sites, albeit with only seven examples at Fontbregoua. Broadly, western Alpine assemblages are comparable with Chasséen open-air sites in the Rhône Valley lowlands and south of the Massif Central (Martin, 2016; Jesus et al., 2020). This is also indicated in western Alpine ceramic assemblages, consistent with Chasséen typologies in the Prealps, including at Trou Arnaud, and in the internal valleys at Le Chenet des Pierres (Savoie), reinforcing the extension of the Mediterranean cultural sphere across the Alps (Borrello & Willigen, 2011).

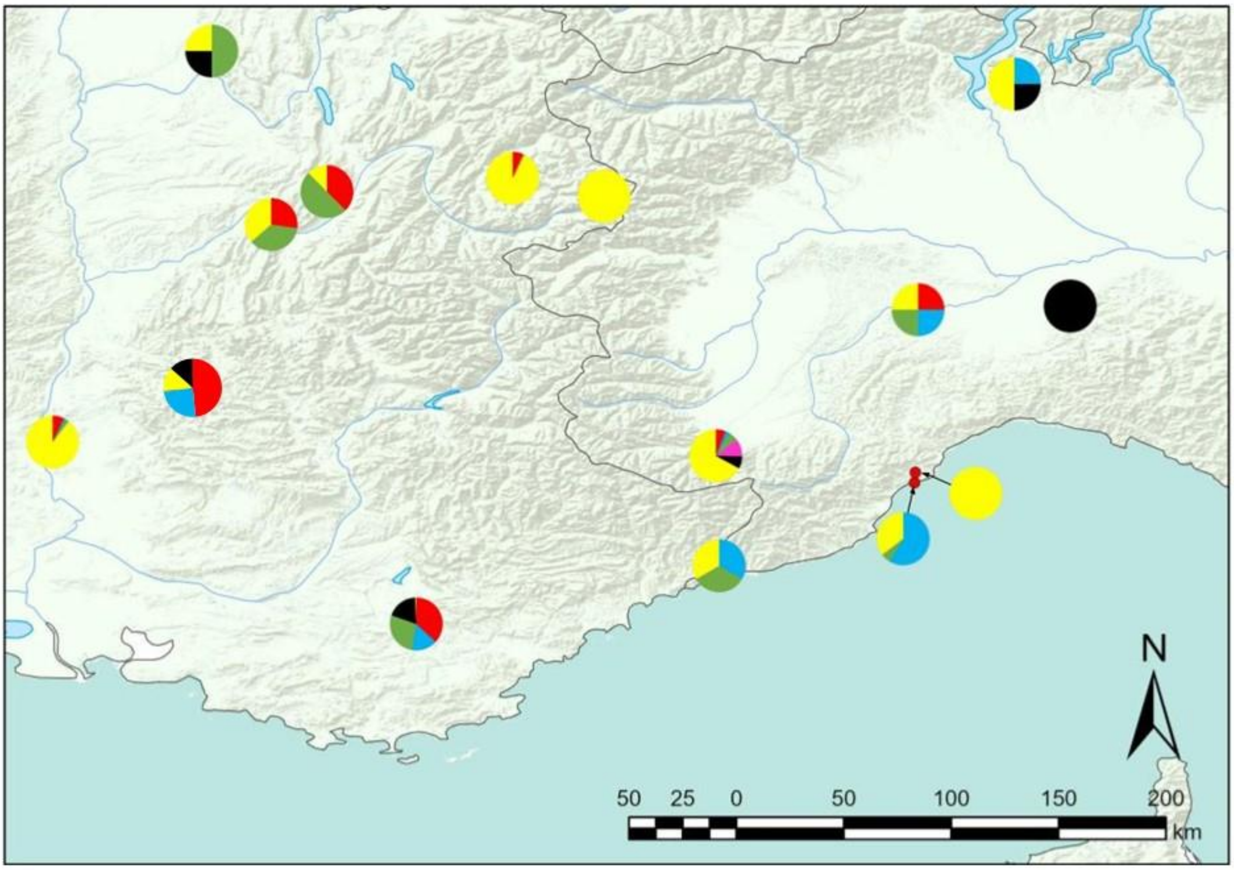


FIGURE 13. MIDDLE NEOLITHIC 1 SITES IN THE WESTERN ALPS; T. NUDUM AND T. MONOCOCCUM ARE COMMON IN THE WESTERN PREALPS, WHILE HORDEUM VULGARE IS PREVALENT IN THE INNER ALPS AND NORTHERN ITALY.

Nevertheless, a distinct preference for *Hordeum vulgare* was observed as groups travelled deeper into the Alpine landscape. Within the internal valleys of Savoie, *Hordeum vulgare* represents the only crop at Bessans Le Chateau at 1750m (La Maurienne), and 92.5% of cereals at Le Chenet des Pierres at 940m (Tarentaise). Similarities with low-mid altitude Chasséen farming strategies were observed through the limited presence of *T. monoccocum* and *T. nudum* grains at Le Chenet des Pierres. While the dominance of *Hordeum vulgare* is reminiscent of the VBQ package in northern Italy, this preference was perhaps environmentally influenced. Conversely, at 1720m in L'Aulp du Seuil (Isere), *Hordeum vulgare* is insignificant; Martin (2014) noted cultivation was unlikely on the difficult terrain surrounding the site; thus the crops are representative of the valleys below. Therefore, divergence from broader trends at Savoie is probably linked to mountain cultivation. Nevertheless, the co-occurrence of Chasséen and VBQ influences in the Alpine passes is unsurprising since the MRV was identified as a centre of eclogite circulation networks while the primary eclogite outcrops lie on the opposing side of the Alps in the Aosta Valley and Cuneo (Piedmont) (Bouard & Fedele, 1993; Thirault, 2005).

On the other side of the western Alps, in the Alpes-Maritimes and northern Italy, the influence of groups from southern Italy does not persist beyond the Early Neolithic. Remains from the Middle

Neolithic 1, generally associated with the VBQ culture, are scarce and almost no sites can be considered representative due to their small sample sizes. Most remains were recovered from Valgrana Tetto Chiapello (Piedmont), totalling 4341 remains, albeit 3074 are identified as *Cerealia* type. A low-resolution picture can be summarised: glume wheats retain their popularity, with *T. dicoccum* slightly more popular, present on 9 sites, while *T. monococcum* occurs on 5. Divergent morphological characteristics have been detected in *T. dicoccum* according to their place of origin during the Early to Middle Neolithic in northern Italy, suggesting varieties were chosen with regards to their environmental contexts (Fiorentino et al., 2000). *Hordeum vulgare* remained important, comprising 67% of the identifiable remains at Valgrana Tetto Chiapello, and always present, excluding at Casalnoceto which yielded only poorly preserved *Triticum* remains. *T. nudum* is most common towards the western Po basin and the coast, discreetly present on 5 of the 11 sites, and never dominant. Although, Rottoli & Castiglioni (2008) attested its increasing popularity across the lowlands of northern Italy during the Middle Neolithic at lower levels than in southern Italy. Despite strong connections with the Chasséen culture, with considerably overlapping ceramic typologies, farming practices appear distinct in the VBQ sphere, with a preference for *T. dicoccum* and *Hordeum vulgare*, possibly influenced from the east by the preference for glume wheats in Bulgaria and the Black Sea region (Basso et al. 2006). Even so, the internal Alpine passes undertook the role of highways, resulting in overlapping crop and ceramic assemblages in Savoie, highlighting connections across the Alps.

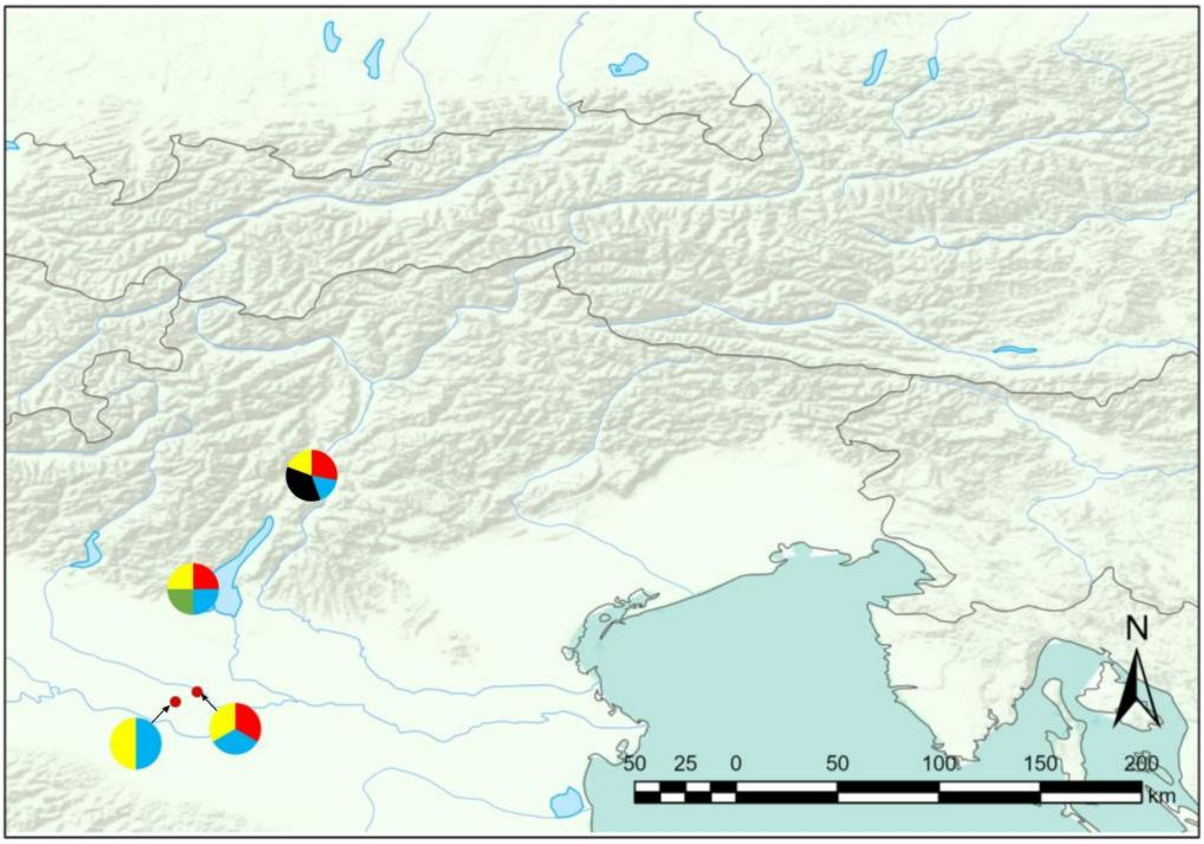


FIGURE 14. MIDDLE NEOLITHIC 1 SITES IN THE CENTRAL ALPS AND PREALPS; GLUME WHEATS AND HORDEUM VULGARE ARE CONSISTENT IN NORTHEASTERN ITALY.

Occurrences of *Pisum sativum* are scattered around the Alpine region, common on the Swiss plateau in significant numbers, and to a lesser degree in the Rhône Valley and Po basin, albeit often represented by an individual specimen, and well-represented in Valais with 69 specimens in Saviese La Soie. While their occurrence is more numerous on waterlogged sites, pulses were not as extensively cultivated as cereals, yet are geographically broadly represented. *Lens culinaris* is rarer yet also widespread, appearing discreetly at Rocca di Manerba (Lake Garda), Egolzwil 3 (Lucerne) and Trou Arnaud (Diois). This limited appearance is likely due to poor preservation.

Linum usitatissimum frequently appears around the lakes of the Swiss Plateau in small numbers, increasing into the Middle Neolithic 2 as the lakes are more densely settled; it is unrepresented beyond this region. *Papaver somniferum* is especially common around Zurich and Zug, often present in high numbers, with 4663 examples at Egolzwil 3. Interestingly, 421 seeds were recovered from Le Chenet des Pierres (Tarentaise) despite being uncommon in the western Alps, described as chance preservation (Martin, 2014). Oilseeds and pulses were likely cultivated in the southern regions, however, due to underrepresentation on dry sites, they were not preserved. This is highlighted by their significant preservation in Middle Neolithic wells at La Bagnoles (Vaucluse) and in the Early Neolithic at Taï (Languedoc) (Bouby et al., 2019; Jesus et al., 2020).

Alpine crop packages adopted a more Mediterranean character by the Middle Neolithic 1, even up to the northern Prealps. Even so, crop packages either side of the western Alps formed distinct subgroups, separated by the high ranges, with *T. nudum* more popular on the northern and western sides, while glume wheats were common in the Po basin. Sites in the internal Alpine valleys demonstrated connections on numerous sides of the Alps, with crop choices mirroring those of the Chasséen through the presence of *T. nudum* and *T. monococcum* and material culture reflecting northern Italian VBQ influences, however their agricultural strategies were adapted to the mountain environment in which *Hordeum vulgare* was preferred.

Middle Neolithic 2 (4100-3500 BC)

Alpine settlement intensified during the Middle Neolithic 2, characterised by population growth and an increase in the size and number of northern Prealpine lake settlements, while crop packages were adapted as agropastoral activity developed at mid-high altitudes. Cultural influences from beyond the Alps are attested in the regional crop packages; however, developing cultural preferences were perhaps ecologically triggered.

The crop package across the northern Prealpine lake settlements became distinctive with rare exceptions. *T. nudum* was most prominent, with *Hordeum vulgare* in secondary quantities. *T. monococcum* and *T. dicoccum*, were frequently found together in smaller numbers. This is consistent across sites associated with Cortaillod, Pfyn and Horgen cultures with minimal variation, illustrating an increasing importance of *T. nudum* into the Late Neolithic. Yield density and reliability was likely prioritised as the population grew, favouring free-threshing wheats which provide high yields for low labour input. Particularly, *T. aestivum* provides the highest yields of all grain species, while suited to nutritious, loamy soils and is relatively frost resistant (Kirleis and Fischer, 2014). The picture between the western (Neuchâtel and Bienne) and eastern (Zurich and Zug) lakes is similar. However, some differentiation possibly arose from greater Central European influences on the eastern lakes, illustrated by the presence of copper and crucibles on Pfyn sites, while western lakes demonstrate more influence from the Rhône (Jacomet, 2007). A slightly higher popularity of glume wheats is possible around the western lakes, although their importance is perhaps overrepresented due to often semi-quantitative datasets from this region. Nevertheless, glume wheats were dominant in two instances: *T. monococcum* was best represented alongside *T. nudum* at Concise Sous Colachoz Ensemble (Neuchâtel), and *T. dicoccum* comprised 63% of wheat grains (and 34% of total grains) at the more representative site, Port Studeli (Bienne). This is interpreted as a site-specific preference at Concise, relating to its long occupation - over 3000 years - in which *T. monococcum* was suitable for a degraded soil (Karg & Markle, 2002). Even so, *T. monococcum* is better represented on the northern edge of Lake Bienne, continuing into the Late Neolithic, possibly reflective of differing topography. While the southern banks are surrounded by the fertile Swiss Plateau, the northern edge backs steeply onto the Jura mountains; the preference *for T. monococcum* may reflect more challenging agricultural conditions and the cultivation of poorer soils (Brombacher 1997).

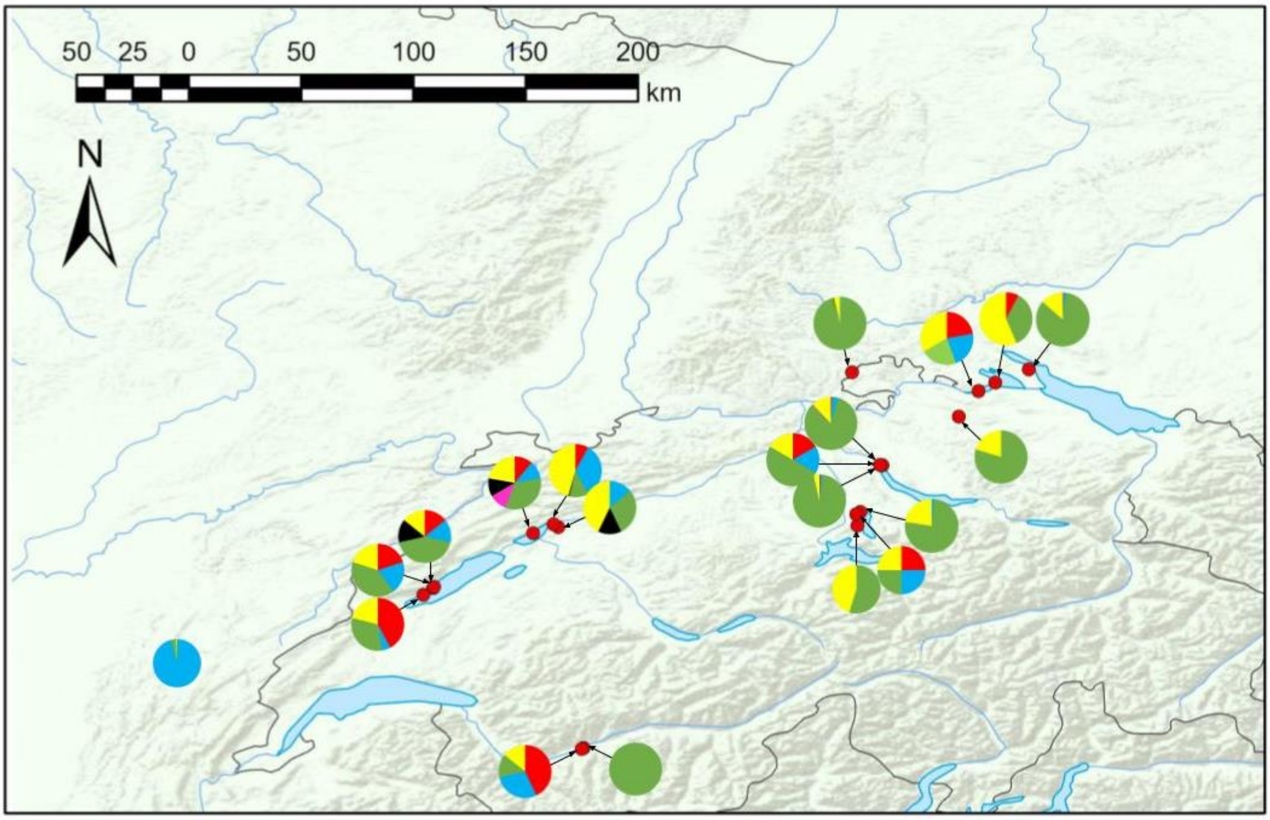


FIGURE 15. MIDDLE NEOLITHIC 2 SITES IN THE NORTHERN PREALPS; T. NUDUM IS VERY COMMON, PARTICULARLY AROUND LAKES ZUG AND ZURICH, WHILE T. DICOCCUM DOMINATES ON THE JURA.

The Valais includes the sites of Av. Ritz, dated to the Middle Neolithic 1-2 transition, and Petit Chasseur (4000-3800 BC). Both sites are associated with Cortaillod material culture, however, the crop assemblage at Petit Chasseur diverges from those at Neuchâtel and Bienne through a joint dominance of *T. monococcum* and *T. dicoccum*. This aligns with the situation in southern France and the Rhône in which glume wheats experienced a resurgence, solidifying the distinctiveness of Valaisian populations from northern lake settlements, and the persistence of Mediterranean influences. However, even further-reaching influences cannot be discounted. Flint from Grand-Pressigny (Loire Valley) was recovered at Petit Chasseur, highlighting the participation of inner Alpine communities in wider Neolithic trading spheres (Affolter, 2011).

The Jura mountains yielded data from just one site - Motte aux Magnins - which displayed a character distinct from the Cortaillod/Pfyn package of the Swiss Plateau; 96% of the assemblage was *T. dicoccum*, with some *T. nudum* and trace *Hordeum vulgare*. Lying beyond the study area on the northeastern edge of the Jura, the assemblage at Gonvillars (c.4700 BC) mirrors this (Schaal et al 2015). This suggests more affinity with groups to the northwest of the Alps, with *T. dicoccum* dominating in Middle Neolithic 2 sites in northeastern France at Au Dessus di Bergis (Franche Comte), Ingenheim (Alsace), and Sole d' Happlincourt (Picardy), perhaps demarcating the boundaries of Alpine identities (Martin, 2016).

Glume wheats regained popularity after 4000 BC in the Chasséen lowlands of southern France; Bouby et al. (2020b) attested the dominance of *T. monococcum* on open-air sites, while Martin (2016) noted increases in *T. dicoccum*, speculated as influences by groups from northern Italy (Jesus et al., 2020). This is not always reflected in the Western Prealps, where *T. nudum* retained its dominance, represented in the Alpes Maritimes, Diois, Var, and even into the Tarentaise, while glume wheats were secondary and *Hordeum vulgare* remained common. *T. nudum* represents over half the assemblage at Antonnaire (Diois) and was identified at Grande Rivoire (Isere) despite the small sample. Delhon et al. (2009) hypothesised the lowland upturn in glume wheats was related to increased soil erosion associated with the intensification of agriculture and anthropogenic fires alongside climatic degradation. Similarly, *T. monococcum* was grown in the Aegean as a reliable buffer crop, often recovered alongside hardy crops, such as *Vicia ervilia*, around poor soils (Valamoti et al., 2011). The later and less intensive arable development of marginal regions perhaps meant Alpine soils were less degraded, thus the shift to glume wheats was delayed (Gallay, 1990). Alternatively, wheat cultivation may relate to site function; ethnographically, *T. monococcum* is cultivated for its strong stems, used in thatch and basketry (Peña-Chocarro, 2009). Notably, most sites in the Western Prealps are caves and rock shelters. Priorities of farmers at these sites possibly differed from open-air sites, considering thatch shelter is less necessary when using natural cave shelters, and concerns centred more around reliable growth and transportation logistics in challenging terrain where free-threshing wheats are lighter and less labour-intensive. However, this is speculative considering the scarce preservation of organic remains on dry sites and discounts the open-air site of Les Chenet des Pierres.

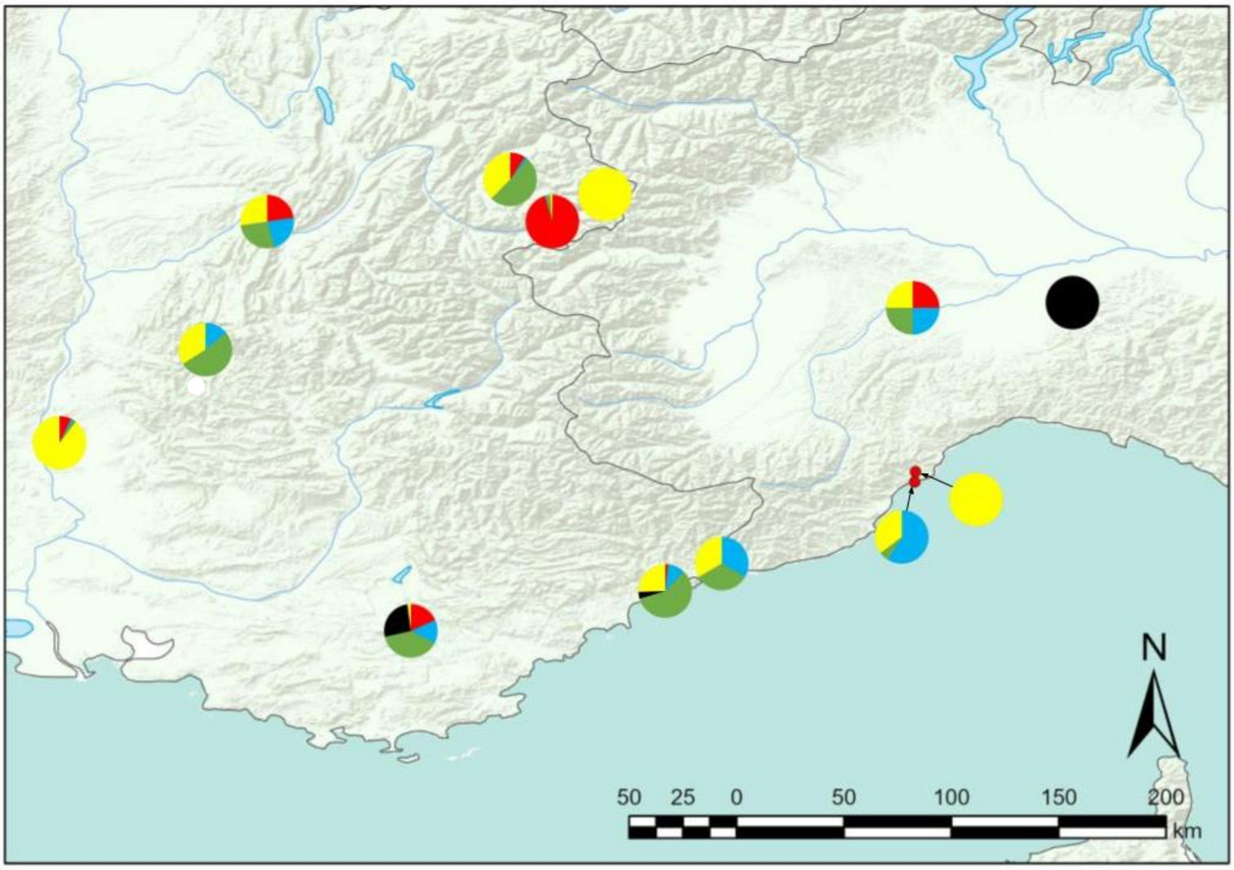


FIGURE 16. MIDDLE NEOLITHIC 2 SITES IN THE WESTERN ALPS; T. NUDUM CONTINUED TO BE WIDESPREAD ALONGSIDE GLUME WHEATS, WITH T. MONOCOCCUM ON THE WESTERN SIDE OF THE ALPS, AND T. DICOCCUM ON THE EASTERN EDGE.

The increased popularity of glume wheats in southern France possibly had climatological motivations, as the lower mean temperatures and diminished precipitation from 4000 BC would affect yields of *T. nudum* (Pala et al., 1996; Contreras et al., 2018). This coincided with changes in subsistence around the western Prealpine lakes, as faunal remains indicate a resurgence in wild animal consumption attributed to crop failure and environmental stress affecting livestock (Kerdy et al., 2018). While the persistence of *T. nudum* in the northern and western Prealps may be surprising considering the widespread climatic deterioration, the higher rainfall in this area perhaps meant yields remained sufficient, despite the cooling temperature. Additionally, morphological variation in *T. nudum* across the lake settlements suggest numerous varieties were cultivated, likely adapted to varying ecological niches and climatic conditions (Maier, 1996). This perhaps highlights cultural differences in adaptation to marginal environments and resilience to climatic stress. While populations north of the Alps were equipped with numerous varieties of resilient free-threshing wheats, those to the south selected glume wheat varieties or shifted between hulled and free-threshing grains to suit environmental needs.

Interestingly, the crop assemblages at high-altitude in La Maurienne and the Tarentaise are heterogenous. The components are reminiscent of Rhône Valley assemblages, comprising *T. monococcum*, *T. nudum* and *Hordeum vulgare*, with *T. dicoccum* almost absent. However, a combination of *T. nudum* and *Hordeum vulgare* dominated at Les Chenet des Pierres (4000-3500 BC), while *T. monococcum* comprises 95% of grains at Les Balmes (3700-3100 BC). The later occupation of

Les Balmes perhaps indicates a delay in the adoption of cultural influences from the south as *T. monococcum* grew in popularity earlier in the Rhône Valley, indicative of the relative isolation of populations in the Alpine passes (Bouby et al., 2020b).

The situation in Liguria and the western Po Basin is less clear due to imprecise radiocarbon dates that span the entire Middle Neolithic, thus impeding understanding of this region. Northeastern Italian sites are more common during the Middle Neolithic 2, however sample sizes remain small. Comparable to southern France, glume wheats and *Hordeum vulgare* dominated, albeit with a preference towards *T. dicoccum*, while *T. monococcum* and *T. nudum* were rarer. *T. dicoccum* is present on all sites in eastern Lombardy, Trentino-Alto Adige, and Friuli-Venezia-Giulia, dominating at the more representative sites of Monte Covolo and La Vela, while *Hordeum vulgare* occurred on every site. *T. nudum* is on 6 of 8 sites, while *T. monococcum* is on 5, neither in dominant quantities. La Vela yielded the only recorded occurrence of the 'new glume wheat' in the Alpine landscape however this may change with reanalysis of earlier-studied material (Jones et al., 2000). Originating in Central Europe and the Balkans, this demonstrates connections with Mediterranean sites south of the Alps, highlighting an important route from Central Europe to the Po Plains (Rottoli & Pessina, 2007; Marinova 2014).

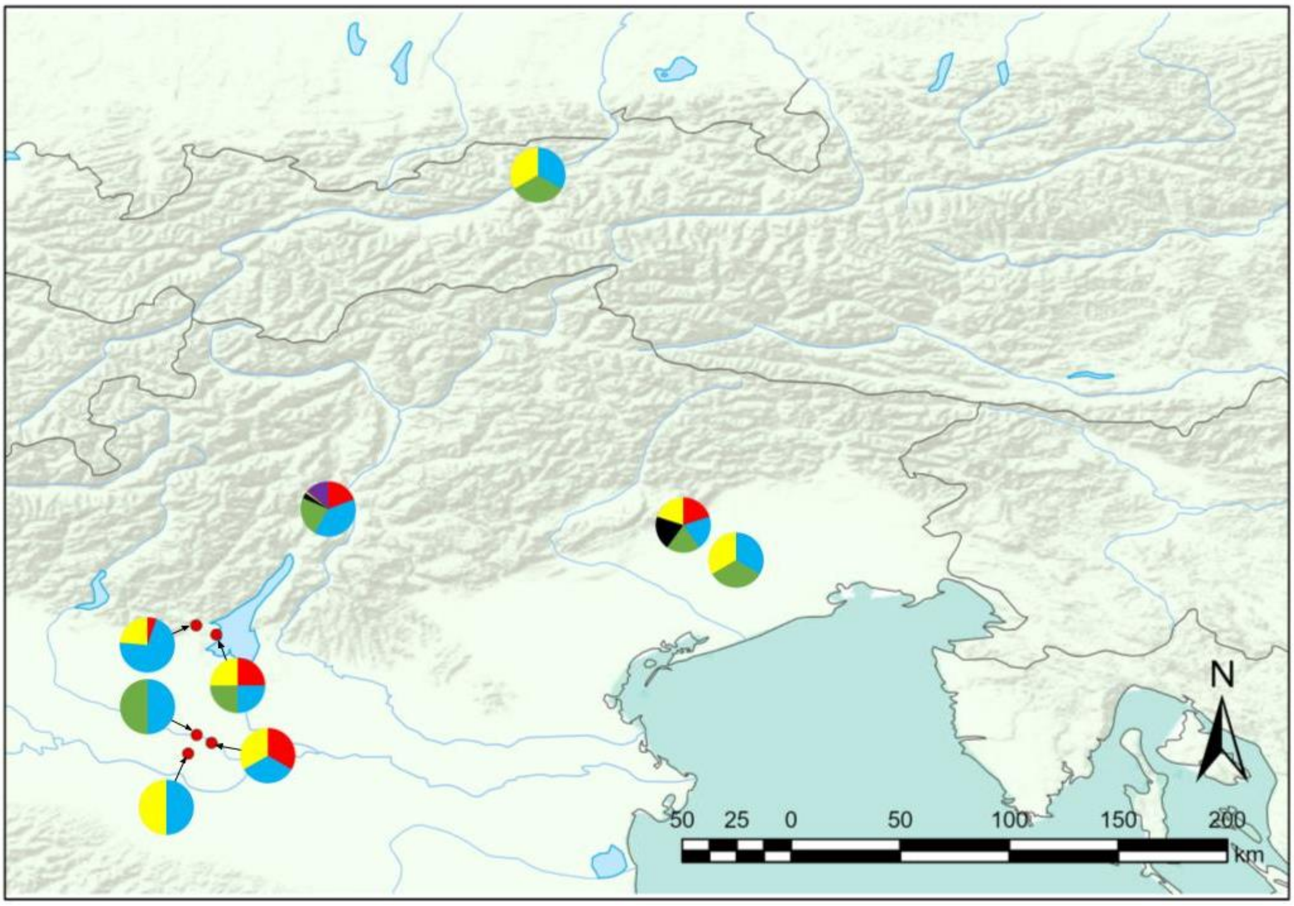


FIGURE 17. MIDDLE NEOLITHIC 2 SITES IN THE CENTRAL ALPS AND PREALPS; T. DICOCCUM ESPECIALLY COMMON ACROSS THE REGION.

Pisum sativum remains well-represented across the Alpine region, generally in small quantities. These are unsurprisingly more abundant in the northwestern Alps on waterlogged sites, but especially around Lake Bienne, possibly relating to different preferences between specific lakes or as a chance preservation. Conversely, *Lens culinaris* is extremely rare, appearing only in the southern Alps at Rocca di Manerba (Lombardy) and Giribaldi (Alpes-Maritimes); this is unexpected considering the high preservation on lake sites, suggesting a Mediterranean character for its cultivation, or a fall in popularity among the cultures of the northern Prealps.

Linum usitatissimum grew in popularity, becoming abundant among the lake villages, particularly surrounding the eastern lakes of Constance, Zurich, and Zug. This popularity is likely attributable to the intensification of textile production, attested by increasing recovery of loom weights, including in Clairvaux and northern Italy, despite its archaeobotanical absence (Rottoli & Castiglioni, 2008; Schaal & Petrequin, 2015). *Papaver somniferum* was abundant across the Swiss Plateau and the Jura; only one instance was recorded in the south, at the waterlogged site of Palu di Livenza (Friuli-Venezia-Giuli). These longitudinal discrepancies are likely based on differing preservation conditions.

Throughout the Middle Neolithic 2, the northern, western, and southern sides of the Alps adopt distinct crop packages through which the Mediterranean character persists. *T. nudum* continued being characteristic of the northern Prealps, while glume wheats dominated to the west and south. The internal alps were agriculturally heterogenous, demonstrating multiple influences suggesting their crossing and contact with lowland groups, however developing independently to reflect their relative isolation and environmental limitations.

Late Neolithic (3500-2500 BC)

The Late Neolithic is characterised by population growth around the Alps, including in marginal high-altitude areas (Gallay, 1990). Consequently, site frequency increased substantially on the Swiss Plateau and the Jura. However, this is not replicated in the Prealps around the Rhône Valley and Po basin, attributable to limited preservation of open-air sites. Thus, crop packages beyond the northern Alps are low-resolution. Nevertheless, nuances in arable practices were identified relating to climatic instability and cultural diversity.

A widespread climate change is documented between 3600-3000 BC, characterised in the European Alps by a falling treeline, wetter conditions, and a drop of 1-1.5°C in summer temperatures (Magny, 2004). At the onset of the Late Neolithic, *T. nudum* continued its dominance across the Swiss Plateau, with *Hordeum vulgare* as closely secondary. *T. dicoccum* regained popularity and was present on almost every site in small quantities, while *T. monococcum* was less significant; glume wheats became more common, possibly as a safety net crop in adaptation to increasingly challenging climatic conditions. This crop package occurs on Pfyn/Altheim sites around Constance (Odenahlen, Zeigelhutte Wallhausen, Sipplingen, but also KanSan on Lake Zurich), dated to the Middle-Late Neolithic transition, and is near identical to those typifying the later Horgen culture, demonstrating continuity in agricultural strategies despite changes in material culture. One exception appears at Horgen sites around Lake Bienne, as *Hordeum vulgare* constituted a higher proportion of assemblages. This may relate to environmental instability caused by oscillations of climatic degradation over the Late Neolithic. Today, the shores of Lake Constance and the western Jura experience more favourable conditions than Neuchâtel, Bienne, and Zurich, thus Neolithic climatic fluctuations were perhaps felt more intensely, necessitating resilient crop choices to ensure yields (Schibler & Jacomet 2010). The continued resurgence of hunting on the Swiss Plateau supports this influence of climate on subsistence strategies in the Late Neolithic (Schibler & Jacomet, 2010).

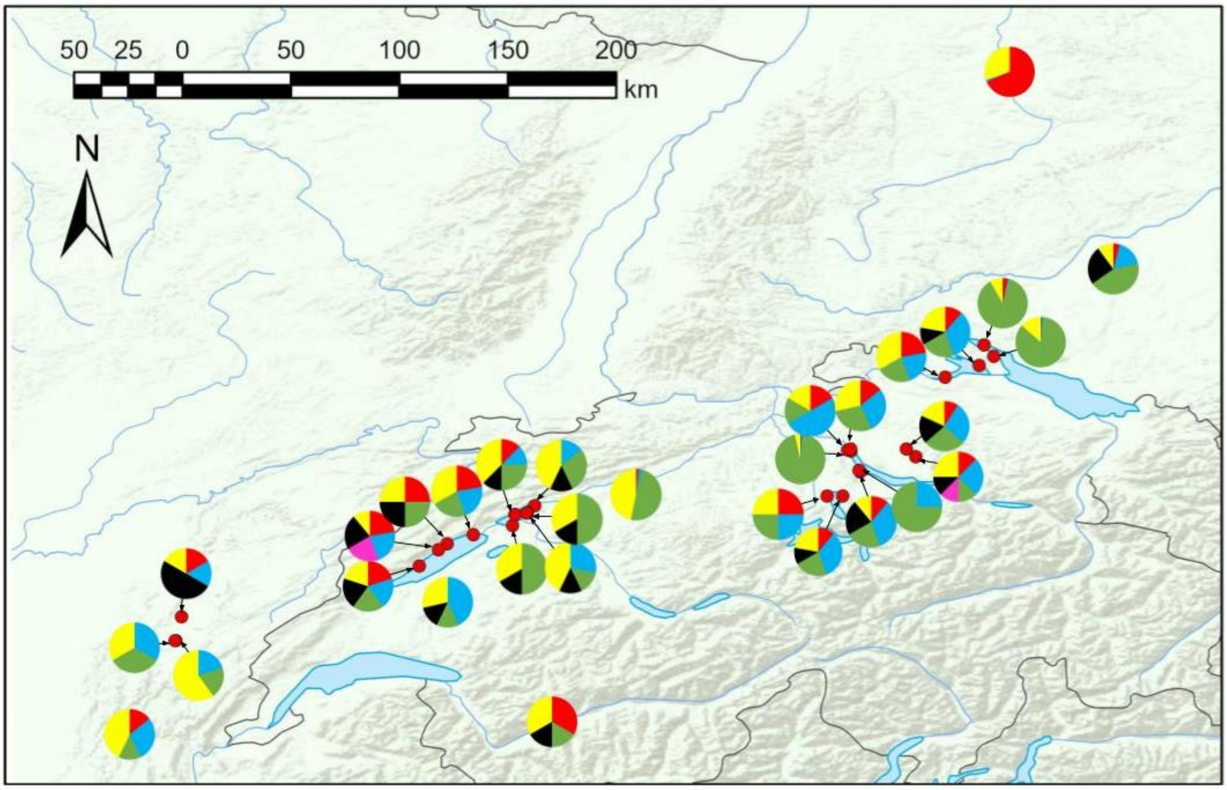


FIGURE 18. LATE NEOLITHIC SITES IN THE NORTHERN PREALPS; T. NUDUM IS COMMON THROUGHOUT, WITH A GREATER POPULARITY OF HORDEUM VULGARE TO THE WEST, CONTRASTING THE T. MONOCCOCUM DOMINANCE IN NECKAR.

The assemblage at Freiberg Geisingen (Neckar), associated with the Schussenreider culture, is an obvious outlier. Bordering the Alpine landscape on the German loess, *T. monococcum* was the most popular crop, while *Hordeum vulgare* is common, and *T. nudum* is present in smaller quantities, highlighting the distinctiveness of the Alpine plant economy.

Saviese La Soie (3500-3100 BC), associated with the Lucherz culture, represents the Valais. *Hordeum vulgare* and *T. monococcum* were equally predominant, while *T. nudum* was rarer. This reduction of *T. nudum* occurred prior to its downturn on the Swiss Plateau. Changes in culinary preferences to reflect identity are plausible as Valasian populations became increasingly culturally distinct; for example, unique settlement structures were innovated in the Final Neolithic through unusual semi-buried circular houses (Mottet et al., 2011). Conversely, climate degradation may have had significant consequences at Saviese La Soie at 850m elevation, necessitating the choice of frost-tolerant crops.

In the latter half of the Late Neolithic, the popularity of *T. nudum* diminishes, reduced in numbers from 3000 BC to its near absence by 2800 BC, particularly on Cordedware/Campagniforme and Lucherz-Auvernier sites clustered around Neuchâtel, but also spanning the Swiss Plateau. This decline coincided with the ascendence of Cordedware culture (Brombacher, 1997). This coincidence was observed at Mozartstrasse (Zurich) in which *T. dicoccum* is equally important to *T. nudum* in Horgen phases but was dominant within the Cordedware levels dated to 2700 BC, while the site of Mythenschloss (Zurich) stands out through its dominance of *T. dicoccum* against the earlier Horgen settlements. *T. spelta* appears discreetly at Surles Rochettes (Neuchâtel) around 2450 BC but was an insignificant crop in the Late Neolithic.

Similarly in the Jura, the Cortaillod sites of Clairvaux Stations II and III include *T. nudum* and *T. dicoccum* in similar proportions with a preference for *Hordeum vulgare*. Subsequently, *T. nudum* was absent on the Clairvux Ancien site of Chalain (3060-2970 BC), and minimal in the Cordedware/Campagniforme site of Derriere La Croix. Similarly in the MRV, *T. dicoccum* comprises 93% of cereals at the Lucherz-Auvernier site of Chavraignes les Baigneurs (2400-2300 BC). The shift towards glume wheats appears consistent across the northern and western Prealps, with a slight preference towards *T. dicoccum*. This perhaps results from its shorter maturation time compared to *T. monococcum*, providing increased reliability during shortened growing seasons in periods of climatic degradation, in which the northern Alps were more vulnerable to this shortening than the warmer climates in the south (Troccoli & Codianni, 2005). Nevertheless, this change was far-reaching, stretching contemporaneously to southern France as *T. monococcum* gained popularity around the Massif Central, persisting into the Bronze Age, implying a more widespread climatic deterioration (Bouby et al., 2020b). Furthermore, climatic stressors were perhaps exaggerated by the impoverishment of soils following the Middle Neolithic intensification of arable farming, including the cultivation poorer soils, and increase of yield densities to accommodate for population growth. An increasing frequency of weeds of nutrient poor soils, such as *Vicia tetrasperma*, *Euphorbia exigua* and *Trifolium arvense*, around Lake Bienne supports this (Brombacher, 1997). Consequently glume wheats were preferred, being less demanding on soils yet cultivatable in both winter and spring (Hajnalova & Dreslerova, 2015).

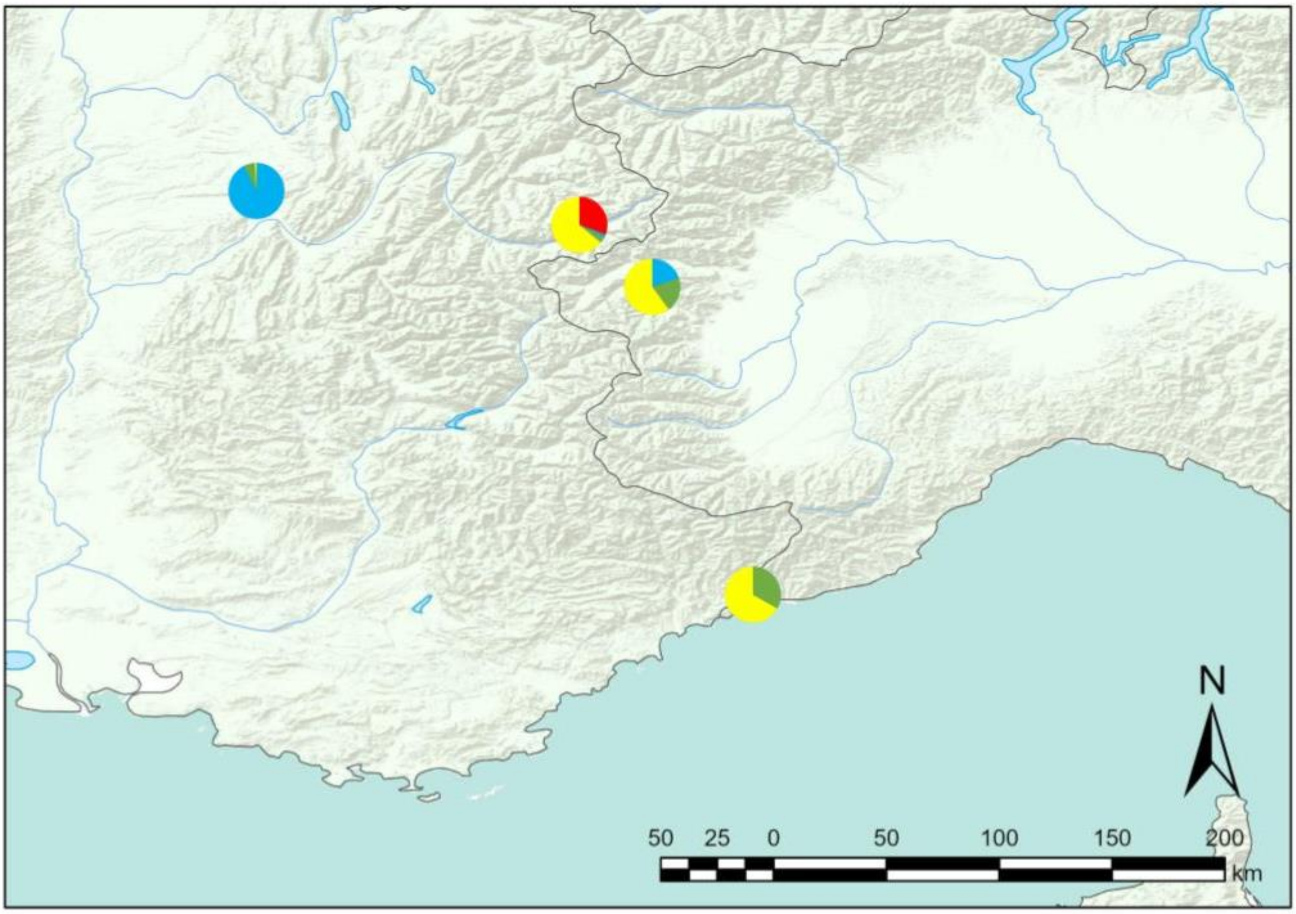


FIGURE 19. LATE NEOLITHIC SITES IN THE WESTERN ALPS; HORDEUM VULGARE DOMINATES THE ALPINE SITES, WHILE T. DICOCCUM DOMINATES THE MIDDLE RHÔNE VALLEY.

There are relatively few sites dated to the Late Neolithic in the Southern and western Alpine areas. The known sites are represented by the caves and rockshelters of Les Balmes (La Maurienne), Balm Chanto (Piedmont), both lying within the montane zone over 1350m, and Pendimoun (Alpes-Maritimes) at 690m. Although Pendimoun produced only 26 grains, *Hordeum vulgare* dominated at all sites, retaining its significance throughout the period. Despite almost a millennium separating the occupation of Les Balmes and Balm Chanto, the popularity of glume wheats persisted, although *T. nudum* was in similar quantities to *T. dicoccum* at Balm Chanto and was the only wheat variety at Pendimoun. While material culture at Les Balmes is consistent with Auvernier-Lucherz and Horgen influences, the preference for *T monococcum* is unusual, thus likely related to a mountain cultivation (Rey & Marguet, 2016).

Hordeum vulgare, and glume wheats are the only cereals represented in the Italian Alps, albeit the most representative site being Monte Covolo (Lombardy) with only 126 grains, while all sites besides the Iceman are dated after 2800 BC. *T. monococcum* was present on all sites, including grains carried by the Iceman mummy (Trentino-Alto-Adige) and at the nearby settlement of Latsch (Festi et al., 2011), thus was likely widely cultivated, however the limited data means the importance cannot be assessed. *T. nudum* is absent, reflecting the situation in southern France and the northern Alps. Even so, the total absence is remarkable, possibly as a continuation of trends from the Middle Neolithic 2.

This reflects arable strategies distinct to the Po plains, that permeated into the mountain communities, as around Latsch and Tolerait (Trentino-Alto-Adige).

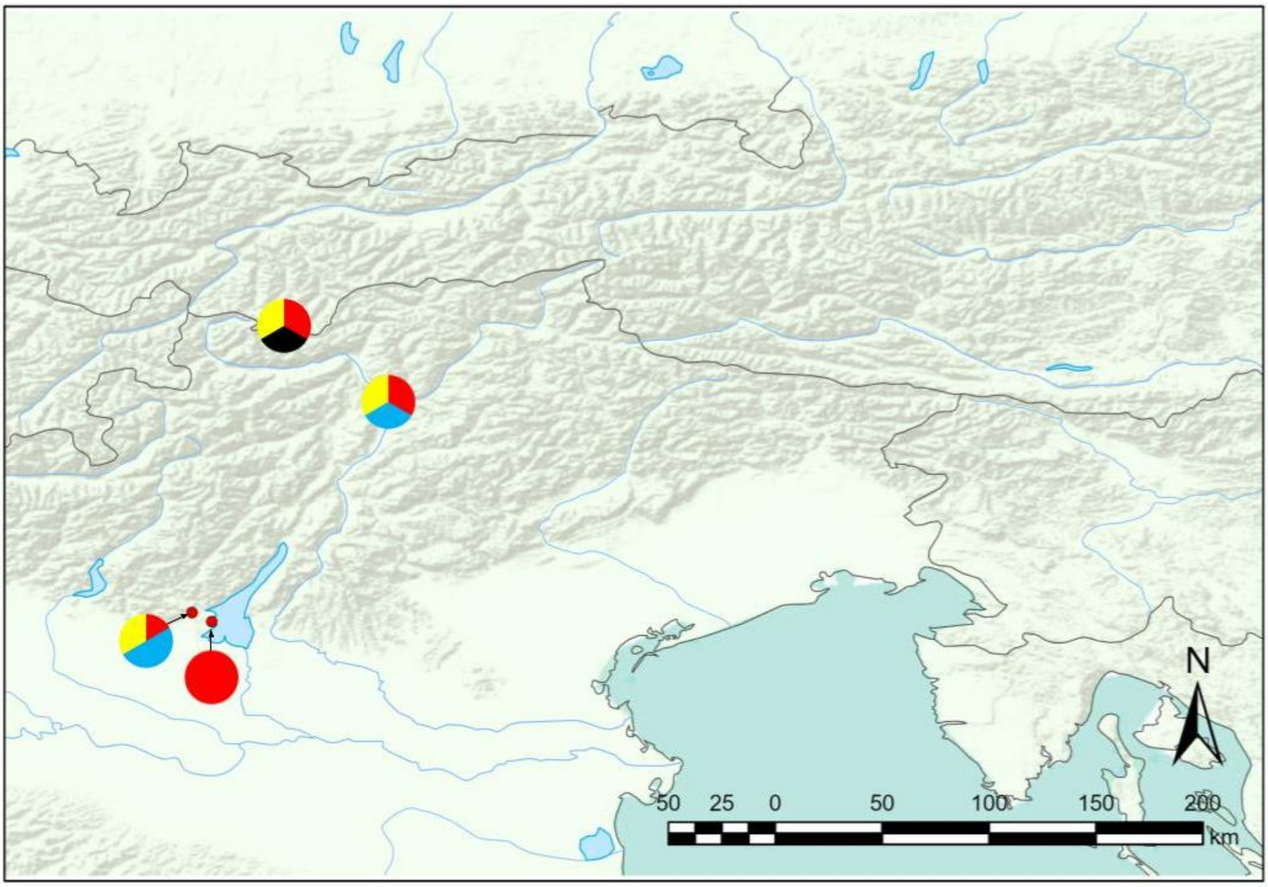


FIGURE 20. LATE NEOLITHIC SITES IN THE CENTRAL ALPS AND PREALPS; T. MONOCCOCUM IS MOST COMMON FROM THE PREALPS, TO THE INNER PASSES.

Pisum sativum declined in the Late Neolithic. Although possibly linked to limited preservation in the southern and central Alps, no pulses were recovered at the Late Neolithic lowland sites of Clos de Roque (Alpes Maritimes) and Mas de Vignoles (Western Rhône Valley) (Figueiral & Sejalon, 2014; Jesus et al., 2020). While widespread in the northern Prealps, pulses were only abundant at Saviese La Soie (Valais), perhaps relating to the independent Valaisian farming strategies where animal proteins may have held less importance. *Lens culinaris* is uncommon, appearing in the northwestern Alpine region in the Jura, Valais and Lake Neuchâtel, and Rocca di Manerba on Lake Garda. Its absence in the northeastern region suggests Mediterranean characteristics.

Linum usitatissimum was abundant across the lake settlement region, particularly on Horgen sites. To the west, it was common in the Jura and MRV, while its absence in the western and southern Alps and Italy is certainly due to preservation and sampling biases. *Papaver somniferum* was intensively cultivated across the Swiss Plateau and the Jura until around 2800 BC, more widely distributed than during the Middle Neolithic. Martin (2014) notes its cultivation dropped in tandem with *T. nudum*. Henceforth, *Papaver somniferum* was absent at later sites, Kempten Wetzikon (2400-2200 BC), Surles Rochettes (2300-2000 BC), and Derriere Le Chateau (2500-2200 BC), despite its previously consistent presence. *Papaver somniferum* was likely cultivated, but less intensely, attested by a drop in its frequency at Mythenschloss around 2680 BC, and Mozartstrasse in 2700 BC. This corresponds with a short oscillation of cooler, damper climate; while cultivation is possible at cool temperatures, levels of opium alkaloids diminish affecting its medicinal value (Magny, 2004; PFAF, 2021). Nevertheless, its popularity remained stable in earlier cold periods, thus the decline likely had cultural motivations.

Despite changes in material culture, Late Neolithic agricultural practices began with some continuity from the Middle Neolithic. After 3000 BC, *T. nudum* significantly declined, indicating an adaptation to climatic deterioration consistent with climate modelling (Magny, 2004). Environmental factors were important influences in agricultural development, although cultural differences in crop packages persisted.

4.2. Adaptation to a marginal environment: cases for mountain cultivation through ecological choices in crop variety

While remaining agriculturally marginal and less intensively farmed than lower-lying regions, the mid-mountain ranges of the Alps possess a long history of arable farming. Contemporary and historical accounts demonstrate the cultivation of cereals and legumes between 1000-2000m altitude, most frequently including *Secale cereale*, *Hordeum vulgare* and *T. aestivum* (Martin, 2014). During the 20th century in Termignon (Vanoise), *T. aestivum* and *Hordeum vulgare* were grown in fields surrounding villages, alongside legumes cultivated in gardens, while *Hordeum vulgare* and *Triticum sp.* 'thrived' in the high mountain slopes around Oisans (Isere) (Allix, 1929, 461; Meillur, 1985). During the Neolithic, cereal pollen levels at Lake Lauzon (Drôme) attest to farming up to the treeline at 2000m by 3450 BC (Argant et al., 2006). While the growth of all main Neolithic crops is possible in the montane stage, certain crops are better suited to harsh conditions, producing higher, more reliable yields. This is reflected through a consistent preference towards some crops, and modification of cultural packages from lower-lying regions. Thus, mountain cultivation is likely from the Middle Neolithic, when mid-altitudes were settled and all mountain stages exploited (Gallay, 1990). Even so, grains were not always cultivated in the immediate environs of the sites; this may relate to the surrounding terrain, or the function of the site, such as on pastoralist camps of short and temporary occupation. At L'Aulp du Sueil, although cultivation was climatologically plausible, grains were likely transported from the valleys due to the steep, shallow soiled terrain of the pass (Martin, 2014). Furthermore, many sites may contain a mixture of crops cultivated nearby and carried from the valleys.

Hordeum vulgare

One of the most winter-hardy crops and grown up to 2000m in Switzerland today, *Hordeum vulgare* was persistently significant at mid-high altitude sites in the Neolithic (Jacomet et al., 1999; Mills, 2006). While consistent in lower-lying regions, it often constituted a higher proportion of the crop assemblage, being common or dominant at sites above 800m, particularly in the western Alps. During the Middle Neolithic, it was the only crop recovered at Le Chateau, Bessans (Maurienne), 71% of grains at Valgrana Tetto Chiapello (Piedmont), and almost half the grains at Egolzwil 3 (Lucerne). In some cases, the importance of *Hordeum vulgare* reflects a modification of the crop package from culturally associated lower-lying regions to a marginal environment; *T. dicoccum* and *T. nudum* took a secondary role at Balm Chanto from 2100 BC (Piedmont). Its overrepresentation in the montane zone is certainly related to its suitability to high-altitude cultivation.

Hordeum vulgare is best cultivated in central and northern Europe on well-drained fertile loam soils, germinating optimally at 20°C in regions with an annual average temperature of 15-30°C and precipitation of 500-1000m, although germination can occur from 3°C (Briggs 1978; MacGregor & Bhatty, 1993). Growth is maximised by cool, low-moisture, bright weather, thus the south facing slopes of the Alps, with limited tree cover provide ideal conditions (AHDB, 2018). Cool temperatures even improve yields, extending the grain filling period to increase dry weight per grain (Riehl, 2019). Although annual mean temperature ranges from a Mediterranean climate in the southern foothills averaging almost 14°C, to -6°C in the high Alps (see figure 21) (EEA, 2009), spring to summer temperatures in the montane zones are within these ranges. Proximal to sites in Maurienne and Tarentaise, Sollieres-Sardieres, around 1300m elevation, averages almost 10°C in summer, and reaches -10°C in winter, with annual mean of -0.8°C (Climate-data.org, 2021). Furthermore, the cooler climate reduces the length of growing seasons in mountainous regions, therefore the short vegetative cycle of *Hordeum* vulgare and early maturation compared to wheats is well-adapted (Mills, 2006; Riehl, 2019).

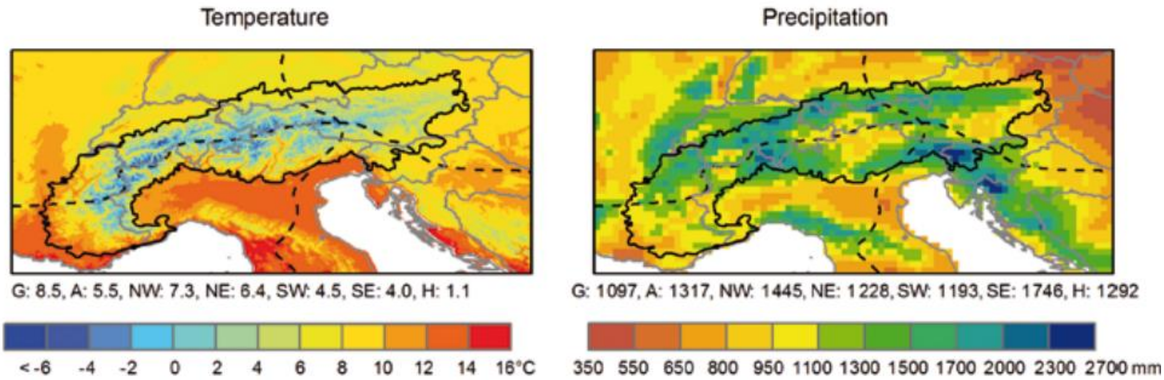


FIGURE 21. TEMPERATURE AND PRECIPITATION IN THE ALPS FROM 1961-1990 (EEA, 2009).

The tolerance of drought and aridity is pertinent in the inner Alpine valleys, which are sheltered from rain by the surrounding mountains. A long history of *Hordeum vulgare* cultivation is attested in these valleys by the place name of l'Orgère (a valley within Maurienne) meaning 'the place where barley grows' (haute-maurienne-vanois.com, 2021). The Maurienne is an arid valley, with similar precipitation to European continental climates at around 1100mm annually, while rainfall in the valleys of the Valais range from 500-900mm (Carcaillet, 2003; EEA, 2009). With lower humidity than the northern Prealps, the limited moisture provides optimal growing conditions, while supporting its popularity in the Mediterranean Prealps.

In marginal environments of harsh weather and poor soils, reliable crops are favoured where other crops may fail. This is especially relevant for Neolithic inner Alpine communities in which a short growing season was accompanied by a scarcity of viable soils, underlining the popularity of *Hordeum* *vulgare*. In analyses of traditional farming in Greece between 1931 and 1960, *T. aestivum* crops failed five times more frequently than *Hordeum vulgare* (Garnsey, 1988). Compared to hardy glume wheats, it is considered a better safety net crop to ensure sufficient yields; particularly in the case of six-rowed varieties, the ratio of crop yield to grains planted is higher than *T. dicoccum* or *T. monococcum* (Cappers, 2008). This is observed in Eastern Qinghai, China, where *Hordeum vulgare* produced yields 1.62 times higher than *T. aestivum* at 3000m elevation (Jia et al., 2016). Reliability is increasingly important if cereals were used to supplement livestock, with both grains and straw historically important as animal feed, while many Classical authors cite *Hordeum vulgare* as the main animal crop due to its reliability and productivity (Mills, 2006; Riehl, 2019). Its significance may be especially relevant considering many high-altitude sites are related to pastoral activity, such as sheepfold caves.

Reliability was possibly optimised using cultivars adapted to mountain climates. While both varieties grow well at altitude, in modern Nepal *Hordeum vulgare var. nudum* is better suited to mountain cultivation than hulled varieties, producing higher grain yields and biomass, while maturing earlier (Matuzeviciute, 2020). Interestingly, free-threshing varieties were associated with the distribution of *T. nudum* in the Neolithic, from the southern European coast to the northern Alps, reinforcing interpretations of a Mediterranean settlement of the inner Alps (Jacomet, 2007). Himalayan Neolithic grains of *Hordeum vulgare* were also noted as more compact, reflecting the thick, strong stems and shorter plants of modern *Hordeum vulgare var. nudum* landraces adapted to the harsh weather of the Tibetan Plateau (Matuzeviciute, 2020). Similarly specialised landraces were perhaps selected for Alpine cultivation; future analyses comparing metrical variation would benefit understanding of past Alpine cultivation if mindful of other factors affecting grain size, such as irrigation, soil quality and agrarian practices.

The inner Alpine popularity of *Hordeum vulgare* peaks in the Middle Neolithic 1, present in all assemblages, while other crops were limited. In these cases, it was likely farmed nearby while other grains were carried to site, cultivated in smaller numbers, or produced limited yields. In the Middle Neolithic 2 and Late Neolithic, wheats formed a higher proportion, with varieties varying culturally in relation to crop packages in the surrounding foothills, although *Hordeum vulgare* remained popular. This could imply wheats were later being cultivated adjacently in the mountains. Alternatively, their mixture with *Hordeum vulgare* may indicate their cultivation as maslins. Often employed as a risk reducing strategy, Martin (2014) proposed joint cultivation could explain the mixture of *T. monococcum* and *Hordeum vulgare* in the Late Neolithic at Les Balmes. However, without statistical comparison of entire assemblages, including weeds, this is challenging to assess. The archaeological proportions of maslin assemblages are highly variable, from equal parts to the survival of only one variety; this is complicated as maslins are often sown as a safety net to ensure the survival of one crop, thus presenting a dominant grain with smaller quantities of the inferior crop, while similar assemblages can arise as relics of past cultivation on the same field, or mixing during deposition (Jones & Halstead, 1995). Furthermore, the early harvest time of *Hordeum vulgare*, which must be reaped immediately upon reaching maturity before yields drop, complicates its suitability to maslin cropping, while its fast growth may smother other crops unless sown ratios are carefully managed (Cappers, 2008). The possibility of strip intercropping within fields remains more likely.

Triticum monococcum

Regarding glume wheats, *T. monococcum* was more consistently preferred around the montane zone than *T. dicoccum*. It formed the dominant wheat variety at Chenet des Pierres (Tarentaise) and Trou Arnaud (Diois) in the Middle Neolithic 1, at Les Balmes (Maurienne) in the Mid Neolithic 2 and at Saviese La Soie (Valais), on the Ice Mummy and the associated settlement of Latsch (Trentino-Alto-Adige) in the Late Neolithic. This is prominent at Les Balmes, representing one of the highest altitudes settled at 1350m elevation, where morphometrical comparison linked the shortness of the grains to cultivation at altitude (Martin, 2014). However, *T. monococcum* may be overrepresented at Les Balmes, where Middle Neolithic grains derived from a single context – a bark storage container – suggesting they were cultivated and stored separate from other varieties (Martin, 2014). Different depositional conditions, such as from mixed storage or a hearth reccurrently used in food preparation, may reveal a contrasting picture; nevertheless, *T. monococcum* held a significant role.

Generally, *T. monococcum* is considered more cold-hardy than *T. dicoccum* (Mills, 2006). *T. monococcum* experiences a lower winterkill, producing higher yields under cooler temperatures, hence its preference at altitudes that experience harsher climates year-round (Bencze et al., 2020). While *T. dicoccum* performed with better stability under more consistent periods of climatic degradation, with yields related to the previous year's crop, *T. monococcum* was tolerant to unpredictable and extreme conditions, common in mountain environments (Bencze et al., 2020). A resilience to lodging is also attested as plants rarely exceed 70cm tall and are strong stemmed, particularly spring sown *T. monococcum* which reaches smaller heights (Zohary, et al., 2013). This improves yields in areas predisposed to intense winds and rainfall; for example, on downwards mid-high mountain slopes during foehn winds, producing unstable weather conditions, and in the Rhône Valley foothills and lowlands due to the Mistral winds, which can reach 90km/hour, bring colder temperatures, and cause severe crop damage (Drobinski et al., 2005; Sharples, 2018). Additionally, selection of grains is suggested, in which *T. monococcum* landraces from the Swiss Plateau to the French Prealps were particularly adapted to the Prealpine landscape, being more frost-hardy, with a prolonged vegetative period compared to contemporary Neolithic landraces, further increasing reliability (Brandolini, 2016).

Furthermore, it is well-adapted to grow on nutritionally poor soils, such as those in the montane zone of the Alps. Particularly at higher altitudes, soils are shallower due to increased erosion, exacerbated by livestock grazing, and sparser land cover, resulting in depleted nutrient reserves (Egli & Poulenard, 2016). In experiments on depleted Sardinian soils, *T. monococcum* performed best against *T. dicoccum* and *Triticum turanicum* in terms of biomass and grain yield (Cadeddu et al., 2021). For Neolithic farmers, this meant cultivation was possible in nutritionally marginal areas, enabling the farming of previously unexploited soils, while fertilisation and labour requirements remained low.

Triticum 'nudum'

It is possibly surprising that *T. nudum* is common, although mostly as a secondary crop, at montane level sites. It represents over half the grains at Egolzwil 3 (Lucerne) in the Middle Neolithic 1, appears dominant at Antonnaire (Diois) and Les Chenet des Pierres (Tarentaise) during the Middle Neolithic 2, and is persistently present in the Valais. *T. nudum* is frequently preferred due to its low labour input compared to glume wheats, and possible culinary preferences. While its growth between 1000-2000m altitude is possible, yields may be reduced or less reliable; free-threshing wheats suffer in degenerated climates and require a higher nutrient input than glume wheats, suggesting a strong cultural or socioeconomic preference was valued over reliability at some sites (Martin, 2014). Although its frequent coincidence with reliable crops, for example *Hordeum vulgare* and *T. monococcum* at Les Chenet des Pierres, may reflect its cultivation alongside other cereals as safety nets. Alternatively, *T. nudum* grains were possibly transported to higher altitude sites following their cultivation in nearby valley bottoms. Weed taxa in Neolithic assemblages from the Valais (La Soie, Tourbillon, La Gilliere, and Les Saturnales) support this, suggesting a mainly summer cultivation of wheats without evidence for high-altitude cultivation (Martin, 2015). Even so, specific cultivars were perhaps selected for cultivation in mid-mountain ranges. Compact varieties of free-threshing wheats, such as *Triticum compactum,* are more resilient to extreme weather conditions due to sturdier, shorter forms and robust stems, and were cultivated in the Bronze Age Himalaya for their mountain hardiness (Matuzeviciute et al., 2020). However, identification of *T. nudum* varieties is uncommon in archaeobotanical material due to overlapping morphological characteristics of the grains.

4.3. Summarising remarks on cultural, socioeconomic, and environmental motivations in Alpine cultivation

Cultural preference towards grain varieties clearly played a role in crop package development, with shifts in preference often coinciding with material cultural change. Through a spatial analysis of the distribution of the most significant crops, the main pathways into the Alps and cultural influences upon populations farming the Alpine landscape can be observed, including a broadly Mediterranean character up to the northern Prealps, and the influence of Balkan and Central European groups on southern Alpine agricultural strategies. Nevertheless, variation exists within cultural boundaries, elucidating the presence of subgroups within the broader sphere. Although the high Alps were crossed, evidenced by far-reaching resource exchange networks, Alpine topography partially informed the extent of cultural groups. Differences in crop parcels were consistently detected between the Rhône Valley, the Swiss Plateau, the Po Plains, the Valais, and the Jura, while distinct cultural hubs were centred around specific lakes or valleys. In numerous instances, crops were selected for their properties in relation to environmental conditions or climatological events. As the climate deteriorated from the Middle Neolithic 2 and accelerated into the Late Neolithic, glume wheats regained popularity despite their labour-intensive cultivation and smaller yields. Crop packages take on a different character on higher-altitude sites, characterised by the overrepresentation of *Hordeum vulgare* and *T. monococcum*, possibly indicating the cultivation of resilient crops in the montane mountain stages.

The crop assemblage from the Middle Neolithic site of Trou Arnaud provides a good example of early settlement of the mid-mountain stages of the western Alps, demonstrating similarities with broader Chasséen crop strategies, and adaptation to a marginal environment of the Roanne Valley within the Diois. Although the choice of grain varieties was clearly related to preferences in the lowlands, it was adaptated to perform well on the poor soils and intense weather conditions of the Prealpine slopes. Furthermore, the association of the southwestern Alps with Mediterranean populations was reinforced through the preference towards glume wheats.

5. Case study: an archaeobotanical perspective on the Chasséen agropastoral site of Trou Arnaud

An analysis of the plant material from Trou Arnaud is presented in the following chapter. The assemblage, dominated by glume wheats, is atypical compared to the crop packages of lowland Chasséen sites, while the abundance of cereal remains is unusual for a sheepfold cave. This underpins its usefulness as a case study into the agricultural and socioeconomic marginality of mid-mountain sites during the Middle Neolithic. Subsequently, the character of human-environment interactions at Trou Arnaud was explored, particularly relating to crop cultivation in a mid-mountain ecotone, and the role of Prealpine cave features within an agropastoral context.

5.1. Results of macrofossil analysis

The tabulated results of plant macrofossil analysis from Trou Arnaud are presented in Appendix 6, and a catalogue of identified taxa in Appendix 7. Material derived from two layers, B and E, and the unstratified Galerie des Pots; radiocarbon dates and the character of occupation layers is detailed in Appendix 4, and site plans in Appendix 5. 5229 remains were identified, all of which were charred, and near wholly comprised of crop remains, mostly cereal grains. Preservation was varied, and often poor from contexts notwithstanding the Galerie des Pots, while few weeds or wild taxa were preserved. The results of this analysis are discussed in the following sections in relation to farming around Trou Arnaud and its integration into the agropastoral economy of the Alpine Neolithic.

5.1.1. Comments on taphonomic processes, dating and sampling

The depositional circumstances of charred plant macrofossils from Trou Arnaud has certainly affected the range of taxa and remains represented. On many dry sites, plants are preserved following events of accidental burning, such as culinary accidents concentrated around hearths, or destruction of the settlement by fire. Consequently, the material from Trou Arnaud was mostly derived from hearth contexts or areas of charred sediment from occupation layers (see figures 54 and 55 in Appendix 5). While hearths may represent a single depositional event, providing a snapshot of culinary choices at one time, assemblages deriving from hearths of repeated use are more common. These yield accumulated material from over a period of use, like samples from the broader occupation layer, pits, or ditches, and represent domestic waste from crop processing, food, fodder, structural remains or dung (Jacomet, 2012). However, generally, hearths are related to culinary processing on domestic sites; fruit and crop seeds are usually best preserved, although some species, such as oilseeds, are more vulnerable to the charring process. (Boardman & Jones, 1990; Märkle & Rösch, 2008). Trou Arnaud is typical of this, with most remains from layers B and E related to food processing from hearths or storage contexts, represented mainly by subsistence crops and traces of local wild taxa, present as contaminants or used as food, fodder, or fuel. Unfortunately, the precise context of material from the Galerie des Pots is unknown, however it is noted seeds largely derived from a collection of hearths and burnt deposits (Daumas & Laudet, 2012). These likely also related to cooking waste, and accidental burning of stored crops and plant resources.

Additionally, uncharred plant remains, assumed of recent origin, were recovered from numerous samples, mainly represented by seeds of local wild flora. This suggests some post-depositional disturbance of sediment, or contamination of samples during or after collection. The mixing of macrofossils from different contexts cannot be discounted, affecting the validity of individual samples, however, this does not limit broader analyses when the total assemblage is examined.

Notably, the botanical assemblage at Trou Arnaud is comprised mainly of cereal grains. This limited representation of smaller remains, including chaff and weed seeds, is almost certainly attributable to the use of coarse meshes during the sieving of samples. Additionally, the overrepresentation of samples from domestic hearth contexts means wild taxa, especially inedible species, are less likely to have been preserved, alongside those related to structures or livestock littering. Furthermore, remains vulnerable to the charring process are scarce or absent. Weed seeds comprise a trace percentage of remains, while plant foods that were likely consumed raw as salad, including *Chenopodium*, are rare. Additionally, no oilseeds were recovered, although it is uncertain whether this relates to preservation, or their limited cultivation. The chance preservation of 421 *Papaver somniferum* seeds at the contemporary site of Les Chenet des Pierres attests to their mid-mountain cultivation, thus the absence of these taxa does not indicate their unfamiliarity to the farmers of Trou-Arnaud (Martin et al., 2008).

5.2. The character of crop cultivation in the Diois

5.2.1. Growing conditions in the environs of Trou Arnaud

Although, agriculture is the primary productive activity in the Diois today, the Prealps pose a challenging environment for farming (Communauté des Communes du Diois, 2014). The mid-altitude mountain environment has a Mediterranean character, characterised by irregular precipitation, hot summers, prevailing north winds, and good sunlight exposure; the montane slopes are particularly unstable, vulnerable to anthropogenically-induced disturbance, while soils are shallow with limited water retention (Communauté des Communes du Diois, 2014). A high level of interannual variability was noted in environmental conditions, thus agropastoral resources, such as pasture and forage, would vary greatly between growing seasons. Specifically, around Saint-Nazaire-Le-Désert today, crops are cultivated mostly in valley bottoms due to the poor soils of the slopes, while the climate is regarded as more suited to viticulture and aromatic crops, mainly *Lavandula*, than cereals, attributable to the regional high sensitivity to a prolonged frost (Monjaret & Del Bufalo, 2004).

5.2.2. Arable subsistence strategies as inferred from the crop macrofossils

5.2.2.1. Cereal remains

Botanical remains from two phases of occupation at Trou Arnaud have been assessed (see figure 22). At least one sample is attributed to Layer E, dated c.4361 BC (potential range of 4648-4144 BC), while 14 samples derive from Layer B, c.4197 BC (potential range of 4335-3986 BC) (see Appendix 4). Three samples are of uncertain date: the Galerie des Pots and J7-J2, both possibly attributable to Layer B, and internal level 3 from the clay structure in I3, possibly related to layer E. Unfortunately, these samples yielded a significant proportion of the total assemblage, thus J7-J2 has been included within

Layer Bs, and I3 level 3 in Layer E. Nevertheless, clear differences between both phases of occupation emerged, while a broad understanding of cultivation around Trou Arnaud was established in which glume wheats, especially *T. monococcum*, *Hordeum vulgare* and legumes were the most significant crops, while free-threshing wheats were less popular.

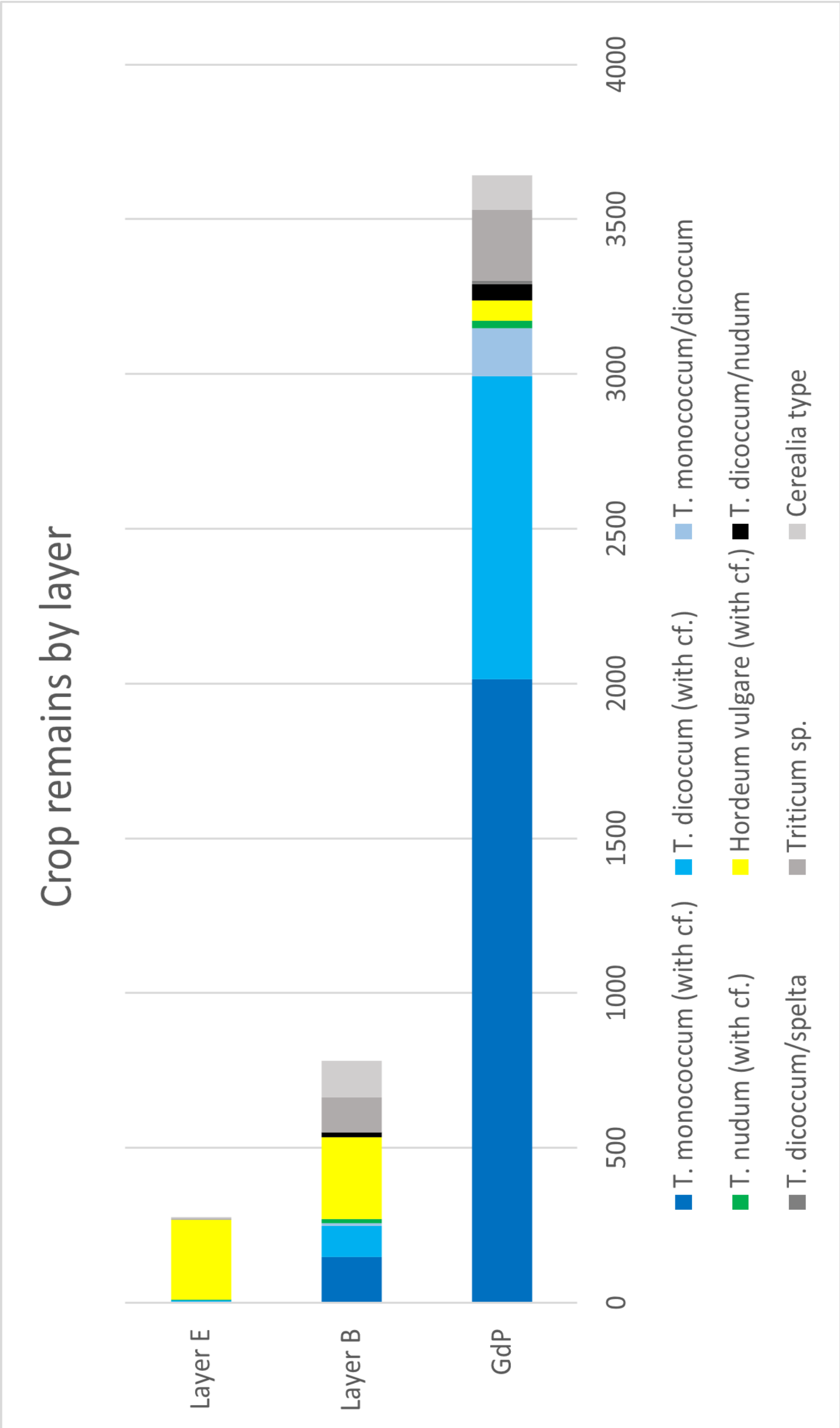


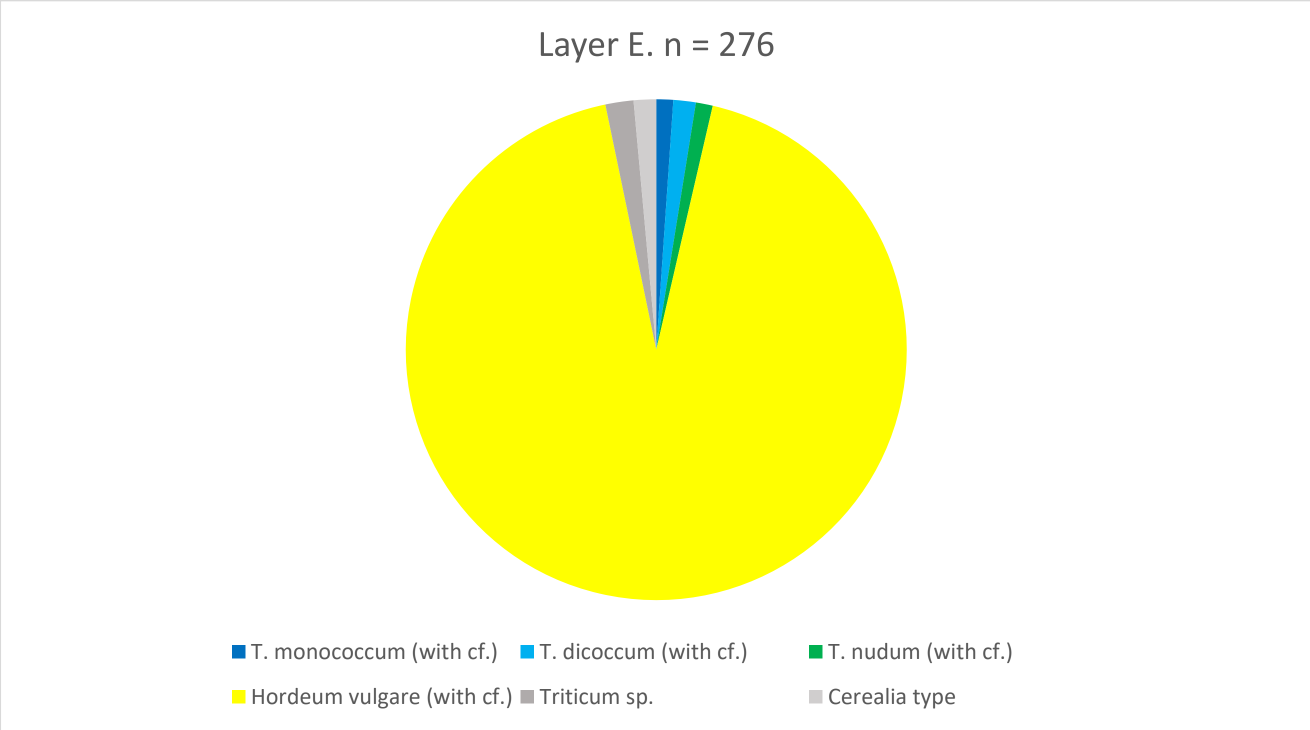
FIGURE 22. CEREAL CROPS FROM TROU ARNAUD ACCORDING TO OCCUPATION LAYER. REMAINS FROM THE GALERIE DES POTS ARE CLEARLY MOST NUMEROUS.

Layer E

Layer E is dated broadly to the middle of Middle Neolithic 1. One sample derives from this layer (M5 no.1923), while one sample, I3 level 3, may also date to the same period. The assemblage from Square M5 is dominated by *Hordeum vulgare*, represented by 200 grains, with trace amounts of *T. dicoccum* (see figure 23). Located within a charred area towards the western cave wall, this sample was collected proximal to many ceramic vessels and other domestic waste, suggesting the grains derive from food preparation or storage. Conversely, the less securely dated remains from sample I3 level 3 are alike samples from Layer B, comprising a diverse corpus of wheats, including *T. monococcum*, *T. dicoccum*, and *T.* cf. *nudum* in equal amounts to *Hordeum vulgare*, although only 19 cereals were identified. While this may relate to site organisation or different depositional circumstances, the insecure dating limits discussion, in which dating to the earlier phase of Layer B is also plausible. A *terminus post quem* of layer E, and a *terminus ante quem* of layer B was assigned to the sample. Further radiocarbon dating of grains may enable better understanding regarding the scale of change and continuity in the plant economy.

There appears a clear preference for *Hordeum vulgare* during the initial occupation of Trou Arnaud, consistent with contemporaneous sites in the Rhône Valley and western Alps. Grains from layers dated between 4400-4200 BC at Le Chenet des Pierres (Tarentaise) comprise an open-air mountain settlement in which *Hordeum vulgare* dominates the earlier phases (Martin, et al, 2008; Martin, 2014). It is also the predominant cereal at Valgrana Tetto Chiappello (Piedmont) between 4500-4200 BC, and the lowland site of Les Moulins, Saint Paul Trois Chateau between 4500-3700 BC (Middle Rhône Valley). This preference may relate to the earliest adaptations to the higher-altitude Prealps and inner Alpine valleys, while *Hordeum vulgare* var*. nudum* was popular across the Chasséen sphere, resulting from Iberian influences (Jesus et al., 2020). Producing high and consistent yields in a diverse range of climates and terrains, *Hordeum vulgare* and glume wheats were preferred as Neolithic farmers faced more environmentally challenging landscapes due to its adaptability and reliability. Consequently, its popularity persisted throughout the Neolithic on the most remote inner Alpine sites. The unstable, frost-prone climate and shallow soils of the Diois necessitated this hardiness, thus *Hordeum vulgare* was prioritised by the first farmers around Trou Arnaud. Once cultivation was more established and consistent, the crop package was diversified as more land and labour could be dedicated to experimenting with other crops.

Notably, the Layer E assemblage contrasts with contemporaneous sites in the northern Prealps, in which a cultural and ecological difference is implied. For example, at Kleiner Hafner (Zurich), *T. nudum* surpasses the importance of glume wheats by the Middle Neolithic, while *Hordeum vulgare* is present but not dominant. This difference perhaps reflects both cultural preference for *T. nudum* to the north, alongside the more humid climate and fertile soils of the Swiss Plateau. This supports the population of Trou Arnaud by Chasséen farmers from southern France, as indicated by ceramic and lithic evidence, where *Hordeum vulgare* was prevalent, reinforcing the notion of the MRV as an initial route into the inner Alps.



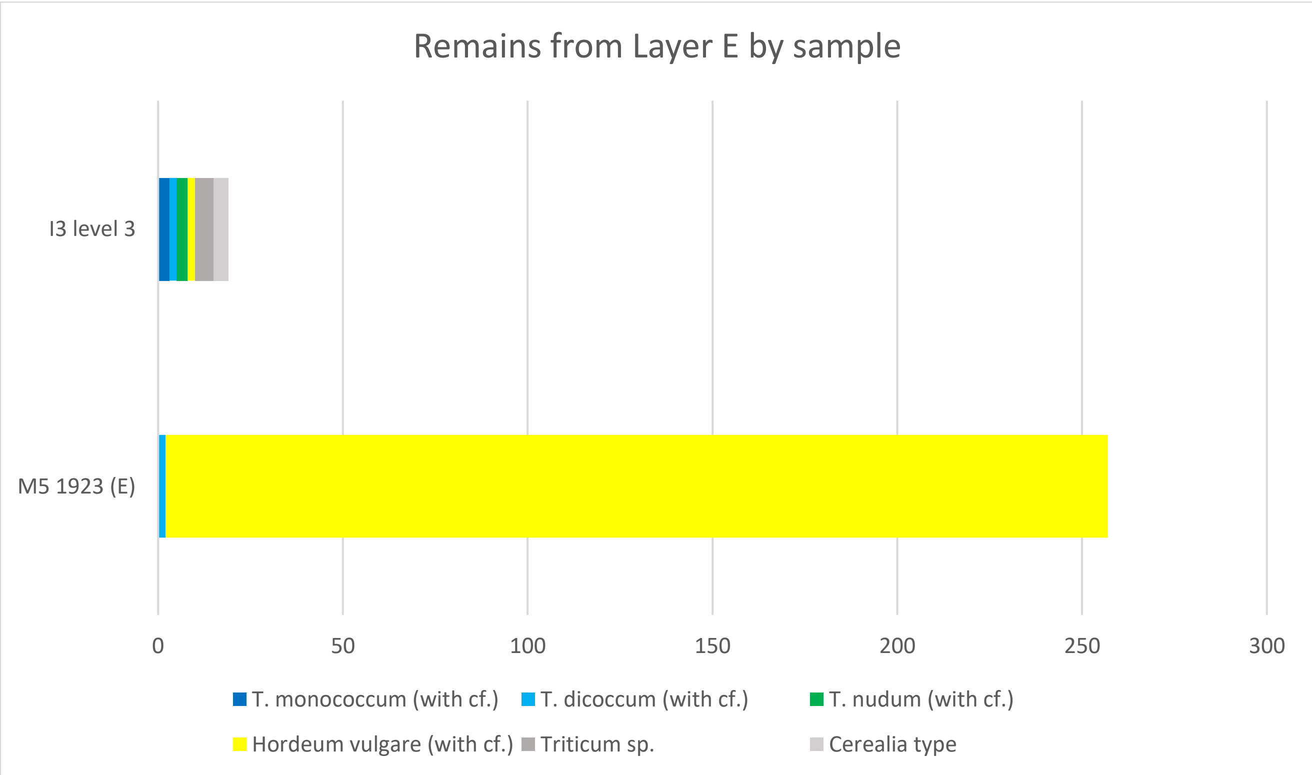


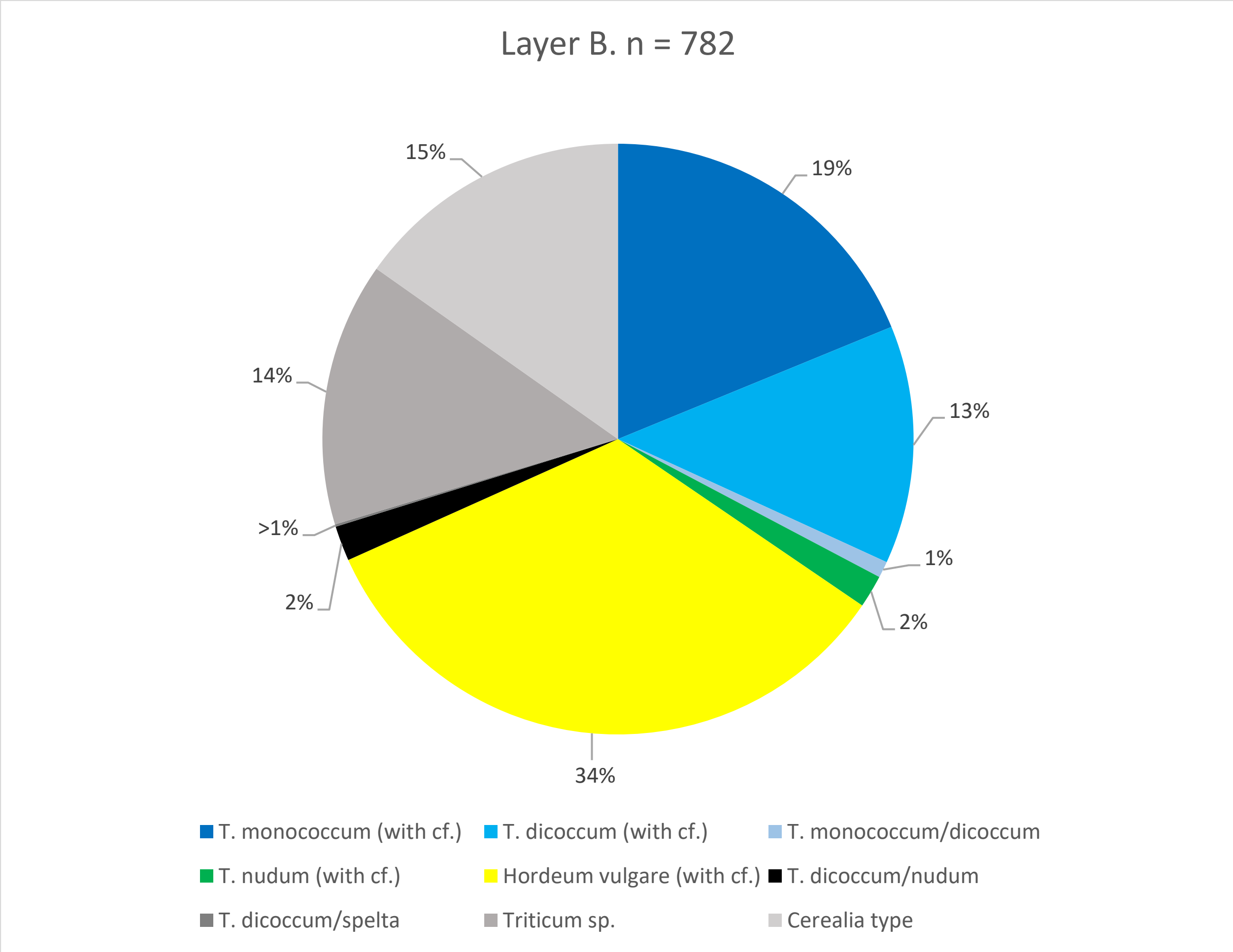
FIGURE 23. CROP REMAINS FROM LAYER E: SAMPLES M5 NO. 1923, AND I3 LEVEL 3. HORDEUM VULGARE CLEARLY DOMINATES.

Layer B

Dated towards the end of the Middle Neolithic 1, and possibly spanning the Middle Neolithic 1-2 transition, the more extensive sampling of Layer B permits the discussion of a more nuanced situation. Although the assemblages are more heterogenous than in Layer E, some broad generalisations can be made. Glume wheats are most popular with a slight preference towards *T. monococcum* over *T. dicoccum*. *Hordeum vulgare* is well represented, although its dominance is confined to the J4b hearth area, while *T. nudum* is extremely limited (see figure 24). Although samples from the Galerie des Pots most likely derive from Layer B, these are discussed separately due to their insecure dating, lack of precise context for samples, and different character of the crop assemblage. Overall, the greater variety of crops represented in Layer B suggests agriculture was well-established and diversified in the Diois by the end of the Middle Neolithic 1, thus crops were a significant component of the subsistence economy.

Notably in contrast to contemporaneous Prealpine sites, free-threshing wheats are almost absent in Layer B, in continuity with the crop assemblage from Layer E. Only sites from the internal Alpine passes (the Middle Neolithic 1 layers of Le Chenet des Pierres and Bessans Le Chateau) are comparable regarding their minimal levels of *T. nudum,* while it remained an important crop until 4000 BC across most of southern France (Jesus et al., 2020). Although *T. nudum* can easily grow around Trou Arnaud at around 720m, *Hordeum vulgare* and glume wheats would have produced more resilient yields, considering the late frosts, high winds, and nutritionally poor soils of the Diois.

However, *T. nudum* may be underrepresented in this dataset. There was a significant degree of morphological overlap between *T. nudum* and *T. dicoccum* grains, exacerbated by the recovery of short *T. dicoccum* caryopses that had become rounded or puffed during the charring process, often retaining glume impressions on the surface. Furthermore, beyond the Galerie des Pots, grains from many samples were poorly preserved, established only as *Triticum* sp. or *Cerealia* type. Similar difficulties in differentiating between *T. monococcum* and *T. dicoccum*, and *T. nudum* and *T. dicoccum* were reported in earlier analyses by J. Erroux due to the abundance of atypical forms (Daumas & Laudet, 2012). Nevertheless, evidence of *T. nudum* is limited even when including those identified as *T.* cf. *nudum* or *T. dicoccum/nudum*.



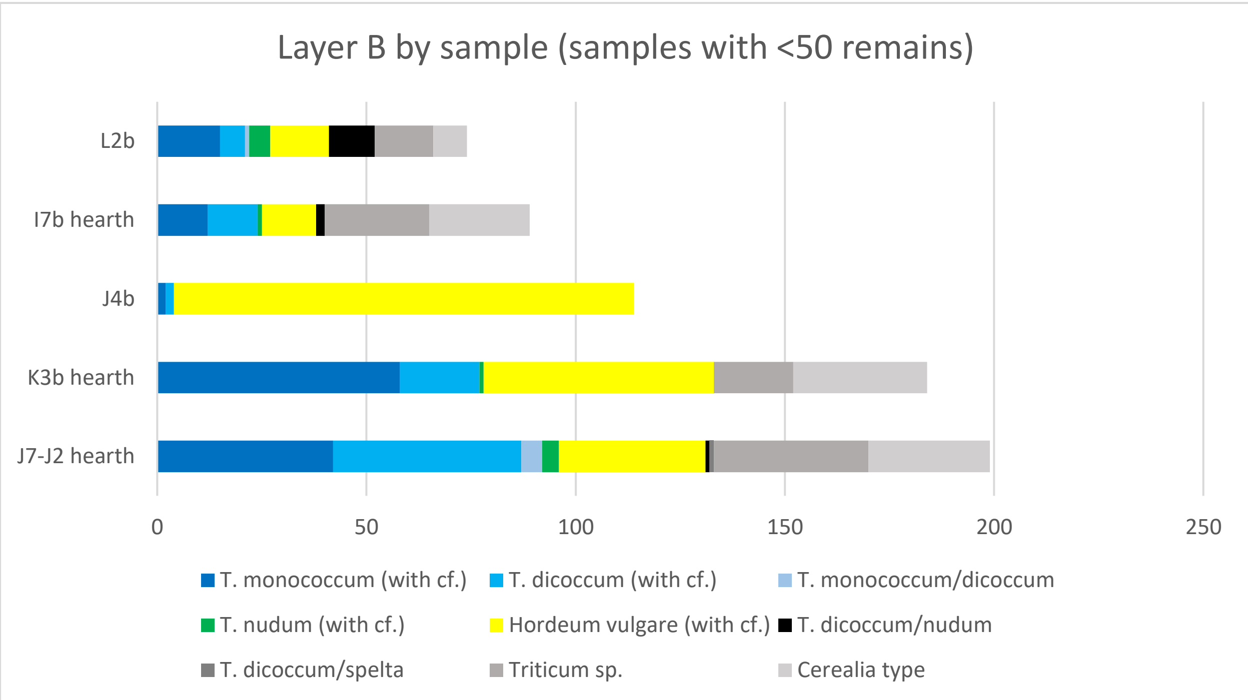


FIGURE 24. CROP REMAINS FROM LAYER B: ONLY SAMPLES WITH OVER 50 CEREAL REMAINS ARE PICTURED. HULLED WHEATS AND HORDEUM VULGARE ARE MOST POPULAR IN RELATIVELY EVEN LEVELS. HORDEUM VULGARE DOMINATES ONLY IN SAMPLE J4B

Glume wheats represent most macrofossils from Layer B. *T. monococcum* and *T. dicoccum* often appear together, and in similar quantities once the possible underrepresentation of *T. dicoccum* due to the cautious identification of atypical forms is considered. Their co-occurrence is consistent across most Layer B contexts, excluding the sample from J4b. Glume wheats were likely chosen due to their high tolerance to harsh weather conditions, while also benefitting from lower nutrient requirements and increased disease and fungal resistance, despite being more labour intensive (Bencze et al., 2020). Glume wheats were plausibly cultivated nearby; the intercropping of *T. monococcum* and *T. dicoccum* is considered impractical today due to their different maturation times, however their frequent cooccurrence suggests these were rotational crops or grown in neighbouring stands, although their joint presence is also plausible through depositional mixing (Reed, 2015).

This preference is not reflected at the neighbouring site of Antonnaire, at which free-threshing wheats were most common, although its contemporaneity with Trou Arnaud is uncertain due to the imprecise dating of both sites. Lundstrom-Baudais hypothesised Antonnaire was occupied later than Trou Arnaud, thus agricultural technologies had advanced to ensure reliable yields of *T. nudum* (Daumas & Laudet, 2012). However, this interpretation assumes that Chasséen farming was advancing towards a preference for *T. nudum* due to its lower labour input, disregarding the possibility of more nuanced cultural or environmental influences on crop choice. This model is unlikely considering the increased popularity of glume wheats after 4000 BC across southern France (Martin, 2016; Jesus et al., 2020). Nevertheless, the dominance of glume wheats at Trou Arnaud precedes this shift in the lowlands. This is well-illustrated at Les Bagnoles (Vaucluse) as macrofossils from the phases occupied coeval with Trou Arnaud are dominated by *T. nudum* from 4250-4050 BC and *Hordeum vulgare* from 4050-3980 BC (Jesus et al., 2020). It was noted the return to glume wheats coincided with temperature and rainfall deterioration in Provence around 4000 BC, however, some smaller scale declines are detectable in the centuries prior (Contreras et al., 2018; Jesus et al., 2020). Alpine ecosystems are especially sensitive to climate change, experienced through harsher weather events, glacial advance or retreat, treeline shifts, and vegetational change related to mountain stages, therefore higher altitudes may have been affected by the earlier subtle declines, while the lowlands remained cultivable (Theurillat et al., 1998). Although at 720m altitude, Trou Arnaud was on the periphery of the most sensitive zones.

Alternatively, the preference for glume wheats at Trou Arnaud may reflect soil quality in the surrounding landscape. The cultivation of glume wheats has been linked to the reclamation of nutritionally poor soils or lands impoverished by persistent cultivation, and was proposed as an explanation for their popularity in the Middle to Late Neolithic as agriculture intensified and more marginal regions were farmed (Martin, 2016; Jesus et al., 2020). The poor soil quality on the limestone slopes around Saint-Nazaire-Le-Désert, when compared to the valleys and alluvial plains of the broader Diois, perhaps necessitated the cultivation of less nutrient-demanding cereals than free-threshing wheats (Monjaret & Del Bufalo, 2004). The popularity of nutrient-replenishing legumes at Trou Arnaud supports this interpretation. This choice likely related to the challenging agricultural potential of the environs, rather than depletion by intensive farming, since the two occupation phases preceding Layer B, appear less intensive, and fleeting in the case of Layer G (c.4460 BC). Conversely, farmers at Antonnaire may have had access to more fertile soils. Cereals were unlikely to have been cultivated on the steep slopes adjacent to the cave, but the site was proximal to the expansive fertile plains of the Drôme valley. It is possible crops were established in the nearby valleys and transported to Antonnaire, while at Trou Arnaud cereals were grown more locally. However, as Trou Arnaud and Antonnaire were not occupied contemporaneously, cultural motivations for these differences cannot be excluded, while sampling at Antonnaire was limited thus likely not very representative.

Although *Hordeum vulgare* is consistently present across most contexts, often appearing in lower quantities compared to wheats, its presence is concentrated around two hearths in the centre of the gallery, well-represented in square K3b, and dominating the J4b hearth area. Reports detailing these contexts note clusters of cereal grains were clearly visible during excavation (Daumas & Laudet, 1998). Unlike remains from the broader occupation layer, which may derive from the cleaning of hearths or ashy sediment having been gradually incorporated into the floor over time, grains from hearths were likely carbonised accidentally *in situ* during food preparation or crop processing and may originate from a single or numerous depositional events. The density of remains alongside the near total dominance of *Hordeum vulgare* in J4b, with *T. monococcum* and *T. dicoccum* as minor contaminants, supports the deposition of this sample as a single incident. Although, deposition during a different season of occupation or relation to different roles between hearths are also plausible explanations. *Hordeum vulgare* is less frequent across other samples from Layer B but still regularly present, often at similar frequencies to wheats, supporting its persistent cultivation around Trou Arnaud since the occupation associated with Layer E. This is consistent with the preference towards hardy crops, further supporting the notion of their local cultivation. However, the crop assemblage from Layer B has a slightly different character to those from the Galerie des Pots in which *Hordeum vulgare* is minimally represented.

The Galerie des Pots

Most comparable to the assemblage from Layer B, the plant remains from the Galerie des Pots are comprised of similar crop varieties, albeit in different proportions (see figure 25). Glume wheats are still predominant, but *T. monococcum* is present in much higher numbers, comprising 45% of the cereal grains, while *T. dicoccum* is well-represented but in smaller quantities (15.76% alongside 11% *T.* cf. *dicoccum*). Although *T. monococcum* is slightly more significant than *T. dicoccum* in Layer B, its popularity is much higher in the Galerie des Pots. Additionally, *Hordeum vulgare* forms only 1% of cereals, and *T. nudum* is still essentially absent. The cereal remains were collected either along the western wall of the gallery or in charred patches on the floor surface (Daumas & Laudet, 1998). This deeper area of the cave was interpreted as a storage zone due to the high frequency of cereals compared to the main area of occupation and their recovery alongside many small ceramic vessels. The abundance of macrofossils may relate to the carbonisation of crop stores, thus the dominance of *T. monococcum* must be considered in this context.

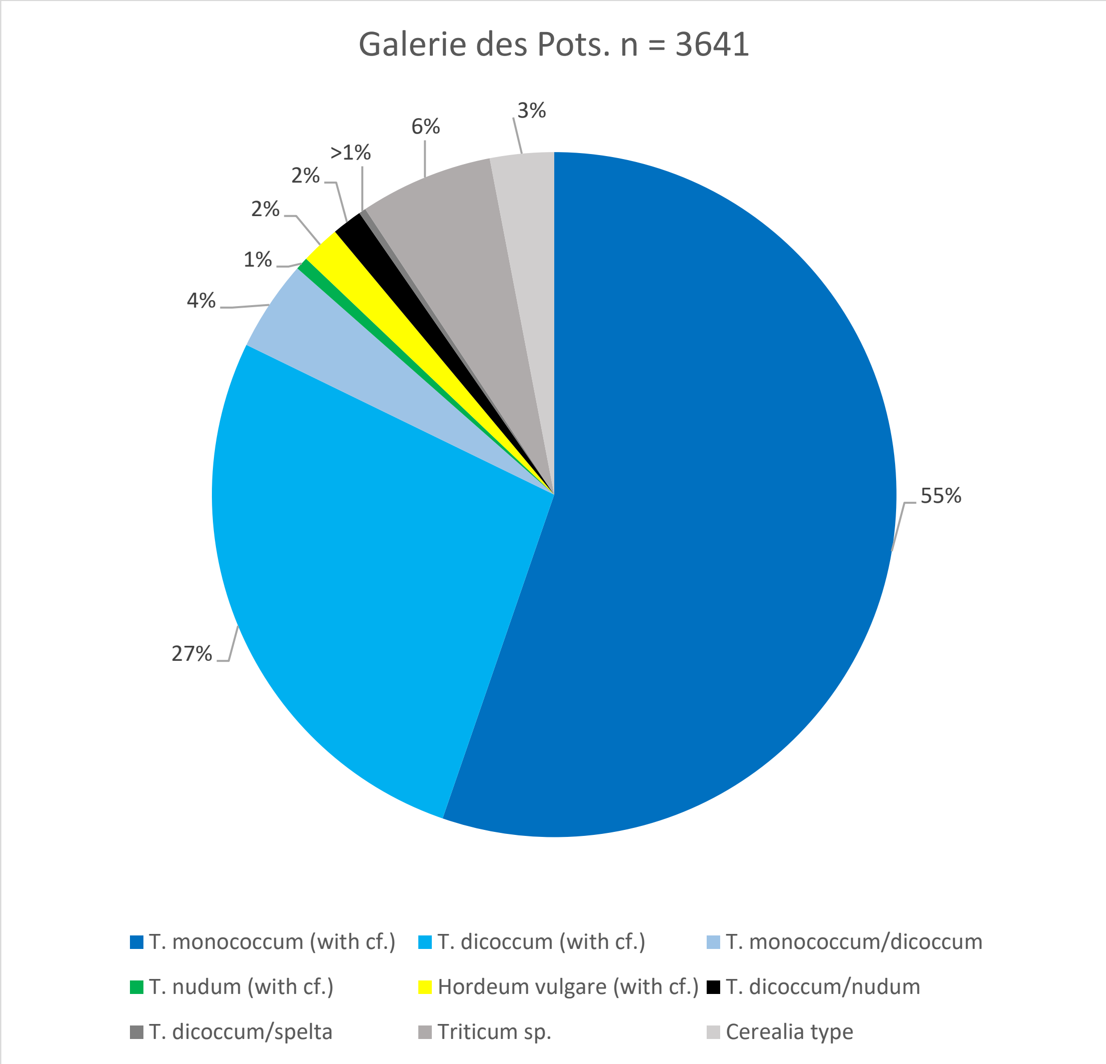


FIGURE 25. CEREAL MACROFOSSILS FROM THE GALERIE DES POTS. TRITICUM MONOCOCCUM CLEARLY DOMINATES.

Glume wheats, *T. monococcum* and *T. dicoccum*, both occur in significant quantities compared to other crops; these grains may have been grown and stored together, although this is difficult to interpret with limited recording. Environmental conditions around Trou Arnaud would support the cultivation of both hardy varieties, for example in neighbouring fields or stands. However, the significance of *T. monococcum* in the Galerie des Pots assemblage may reflect its greater suitability to the wide-ranging weather conditions and nutritionally poor soils characteristic of the Diois. Even disregarding the corpus from the Galerie des Pots, *T. monococcum* was the most important grain at Trou Arnaud, likely due to its adaptability to the environs, contributing significantly towards the diets of its occupants.

As the limited contextual information and dating of remains restricts analyses regarding the Galerie des Pots, the subsequent discussions are founded on some assumptions, based on interpretations of the stratigraphy and organisation of the gallery by Daumas and Laudet (1998; 2012). These are, firstly, that most grains date to the same phase, likely Layer B, and were carbonised simultaneously during one season of occupation. Also, that most grains derive from crop stores based on their relationship with possible storage areas and proximity to clusters of ceramic vessels, while macrofossils from hearths held a more even distribution of crop varieties. We can speculate that the dominance of *T. monococcum* in comparison with other contexts reflects a season of its especially successful growth, or reduced yields of other crops. This may have been induced by a season of unpredictable weather, common in the Roanne valley, including low rainfall or a late frost, although this does not account for the underrepresentation of *Hordeum vulgare* (Bencze et al., 2020).

Alternatively, the proportions of grains perhaps reflect the different maturation times of cereal crops, with small amounts of multiple crops being cultivated and immediately consumed across one season of occupation. Should carbonisation have occurred towards the end of the growing season, storage contexts may yield a lower representation of earlier harvested crops, such as *Hordeum vulgare*, and overrepresentation of those that mature later, including *T. monococcum* (Troccoli & Codianni, 2005; Riehl, 2019). This hypothesis is supported by the more even distribution of crop varieties across non-storage contexts in the main occupation area. This scenario suggests a sustained occupation of the cave and cultivation of nearby fields across a growing season, with limited subsistence input from other settlements and minimal generation of surplus, aligning well with a temporary sheepfold camp function. However, this interpretation is speculative and founded on the aforementioned assumptions, the near simultaneous sowing of crops in similar quantities in separate stands, and consumption soon after harvest. Analysis beyond conjecture is difficult in the absence of more precise contextual data and dating.

5.2.2.2. Legumes

Many legumes have been preserved at Trou Arnaud, comprised mostly of *Pisum sativum*, with some *Lens culinaris*. A similar situation was observed at Le Chenet des Pierres, in which *Pisum sativum* is represented by 141 examples in the Middle Neolithic (Martin et al., 2008). *Pisum sativum* appears consistently at low levels across most samples at Trou Arnaud, however is abundant in the J4b hearth area alongside some *Lens culinaris*. This context is likely linked to food preparation, suggesting legumes were an important component of the inhabitant's diets. Additionally, although the sample size is limited, *Pisum sativum* forms 46% of the macrofossils in level 1-2 and 27% of level 3 from the clay structure in I3, while *Lens culinaris* is also present. Furthermore, the interior wall of the clay silo yielded higher levels of *Fabaceae* pollen (2.57%) than a cross section of the entire vessel (0.74%), suggesting *Fabaceae* was held within the structure (Argant et al., 1996). *Pisum sativum* was possibly popular as it provided broader consumption choices than many crops as it can be consumed fresh or cooked, adding culinary variety. Consequently, this affects the preservation chances of legumes, being less often exposed to burning, while the softer endocarp decreases the chance of surviving charring, particularly at higher temperatures (Fuller & Harvey, 2006).

The high representation of legumes may relate to their cold tolerance, thus suitability to cultivation at altitude and ability to provide a consistent source of protein while being less labour intensive than livestock. *Pisum sativum*, especially, was the highest yielding of the available Neolithic pulses and generally tolerant of a wide range of conditions, attested by its growth up to 2000m altitude in the Valais today (Jacomet et al., 1999; Kreuz et al., 2020). Presently in northern and central Europe, it is often spring sown to avoid frost damage on the first flowers, but is generally regarded as frost hardy, thus is a winter crop in much of southern Europe (Macák et al., 2020). *Lens culinaris* is notably more fragile than *Pisum sativum*, accounting for its less frequent occurrence at Trou Arnaud and other

Prealpine sites. However, it still represents a relatively cold tolerant crop and different cultivars could be selected for their adaptability to southern Alpine climates; today in Mediterranean environments different cultivars have variable yield responses to cold and reduced rainfall, in which cold tolerance is a more common characteristic (Erskine & Ashkar, 1993). Well-adapted to a variety of climates, including the mountain-Mediterranean environment of the Diois, *Lens culinaris* was common both north and south of the Alps during the Neolithic, particularly on LBK sites in northern Europe, and in the Balkans, although generally less significant than Pisum sativum; its presence at Trou Arnaud is therefore unsurprising (Salavert, 2011; Kreuz & Marinova, 2017).

Correlating with the preference to glume wheats, the popularity of legumes may also relate to the low soil quality around Trou Arnaud; a similar situation is notable in the inner Alpine valleys around Le Chenet des Pierres. Nutrient reserves can be replenished via legume cultivation, providing an efficient source of nitrogen fixation, leading to its present-day popularity as a green manure or cover crop (GRDC, 2018; Macák et al., 2020). This is particularly relevant on mountain soils in which nutrient reserves are especially variable and can be rapidly depleted by extensive grazing (Egli & Poulenard, 2016). Legumes were perhaps cultivated to extend the lands suitable for agriculture, or to replenish soils following the production of more nutrient intensive crops, such as wheats, on the naturally poorer soils of the Diois.

Interestingly, *Pisum sativum* is the most common crop around the J4b hearth (in J4b and J4-K4b), cooccurring with significant amounts of *Hordeum vulgare*, some *Lens culinaris*, and limited glume wheats, presenting a different character to the site-wide assemblage. One possibility is the practice of legume-barley combined intercropping. The combined cultivation of legumes and cereals is well documented historically and ethnographically, being the most popular intercropping system on smallholdings in Africa, Latin America, and Asia today (Edjes, 1990). The system was also inferred at the Ancient Egyptian site of Khentkawes, in which *Trifolium* appears abundantly alongside cereals, (Malleson, 2016). Thus, there are numerous advantages to this partnership that are historically well-known and would likely have been recognisable to Neolithic farmers. Combined intercropping heightens the nutrient replenishing quality of *Pisum sativum*, while lessening the impact of *Hordeum vulgare* growth on soils, in which less soil nitrogen is used due to an increased atmospheric absorption (Hauggaard-Nielsen et al., 2006). This results in 17-31% more efficient nitrogen use than sole-cropping, and prevents soil nitrogen degradation and erosion, likely an attractive effect considering the shallow, poor soils on the limestone slopes around Trou Arnaud (Hauggaard-Nielsen et al., 2006). Additionally, the nutrient content of the cereals and forage produced is higher, although grain size may be reduced (Lauk & Lauk, 2008; Frick & Mackenzie, 2016). The practical benefits were perhaps also understood, in which cereals may perform as a nurse-crop for climbing legumes, preventing lodging and increasing disease resistance (Balkcom et al., 2007). This also reduces labour as legumes climb the stems of upright crops, thus the lowest pods are higher from the soil and easier to harvest (Balkom et al., 2007) Overall, legume cultivation was an important element of arable farming at Trou Arnaud, either individually or joint with cereals; their adaptability to the mountain climate and poor soils of the Diois results in a reliable plant-based protein source, that was likely particularly important in times when animal protein reliance was reduced.

5.2.2.3. A mid-mountain cultivation system?

When considering the overall macrofossil corpus from Trou Arnaud, multiple themes are apparent across all samples. The crop varieties cultivated were well-adapted towards colder climates, poor soils, and unpredictable weather conditions including variable winds and precipitation. Less resilient varieties were excluded or rare, such as free-threshing wheats and oilseed crops. This suggests reliable yields were valued, and the Neolithic occupants understood well the limitations of their environment, adapting agricultural strategies in response. The preference towards glume wheats, *Hordeum vulgare* and legumes was plausibly underpinned by their cultivation at mid-mountain altitude, either immediately surrounding the site, or in nearby environs. At Trou Arnaud, agriculture appears particularly influenced by poor soil quality; the most significant crops, especially *T. monococcum*, are noted for their adaptability to nutritionally poor soils, while nitrogen replenishing legumes form an unusually significant proportion of the assemblage (Bencze et al., 2020). This represents some divergence from the broader Chasséen package, in which prior to 4000 BC, *T. nudum* and *Hordeum vulgare* were most popular alongside limited glume wheats (Martin, 2016; Jesus et al., 2020). Meanwhile, the western Prealpine area adopted a heterogenous character during the Middle Neolithic, suggesting arable farming was modified to suit site-specific environmental niches.

Diminutive grain size can also be an indicator of cultivation at altitude. Although grain size can display variability across one harvest or even one ear and is mainly influenced by genetics, physiological stressors, such as drought, cold temperatures, and limited nutrient supply are a common cause in grain size reduction (Reed et al., 2019; Matuzeviciute et al., 2020). Martin (2014) noted that *Hordeum vulgare* and *T. monococcum* caryopses from Alpine sites are generally smaller in length and width compared to those from the plains and surrounding the prealpine lakes, excluding Lake Bienne and at Arbon Bleiche, and was cautiously related to their cultivation at altitude, soil quality or agrarian practices. The crops from Trou Arnaud align well with this observation, as *T. monococcum*, *T. dicoccum* and *Hordeum vulgare* grains appear morphometrically similar to grains from Les Chenet des Pierres (Tarentaise) (Martin, 2014). At both sites, *T. monococcum* grains were especially short, while *T. dicoccum* and *Hordeum vulgare* were slightly larger than those at Les Balmes (Savoie), albeit smaller than on the plains. However, in this case grain size is an unreliable indicator; other variables affecting size, including fertilisation and irrigation practices or unusual climatic events are difficult to distinguish in the present dataset. The possibility of landraces with genetically shorter grains is also plausible, for example the shorter *Hordeum vulgare* caryopses recovered from Tien Shan were reminiscent of genetically distinct mountain cultivars; aDNA analysis of waterlogged remains could be useful in future in identifying varieties (Matuzeviciute et al., 2020). Furthermore, grain size can be affected by charring, with distortion particularly prevalent at higher temperatures; this is accurate at Trou Arnaud in which *T. dicoccum* grains likely became shortened and rounded during carbonisation (Charles et al., 2015).

5.2.3. Understanding of broader agropastoral practices at Trou Arnaud from botanical data

Understanding of past agropastoral strategies, including livestock management, seasonality and harvesting strategies are often inferred from the presence of weeds of crops and pasture based on their ecological characteristics, for example, preferred growing conditions, flowering times, and average height etc. (Jones, et al., 2010). Although this can be affected by the stage of crop processing preserved – by the final stages, after pounding, winnowing, and sieving, most weeds are removed, particularly smaller seeds - this can provide an indication of a site's role in the arable economy (Jones, 1984; 1987). Very few weed seeds were recovered from Trou Arnaud, attributable to the use of coarse sieves when processing samples. Nevertheless, some broad inferences can be made regarding the agropastoral landscape surrounding the cave.

Only two weed macrofossils were collected from layer E; these are *Rumex* (cf. *acetosella*) and *Galium* sp. Notably, both taxa prefer disturbed soils - a common feature of anthropogenic landscapes - and reflect environmental conditions local to Trou Arnaud. *Rumex*, mesoxerophilic weeds, common on poor or acidic soils of permanent grassland or disturbed ground, grow vigorously after clipping, thus are frequently found on pasture (Tison & de Foucault, 2014). Meanwhile, *Galium* species grow in diverse conditions, but are most common on eutrophilic wasteland and the edges of ruderal or arable fields. Their presence also in pollen data from the structure in I3/4 suggests the macrofossils are representative of the vegetation around the cave, further reinforcing the notion of agropastoral activity in the surrounding environs.

Due to poor preservation, weed taxa from Layer B was generally imprecisely identified, only to genus or family level, and mostly represented by single specimens. Most derive from hearth contexts thus likely were contaminants of crops that remained after processing, or result from local vegetation used as fuel, waste from food or fodder, or burnt dung. These were *Chenopodium* (cf. *album*), *Bromus,* sp., *Ranunculus* sp., *Carex* sp., *Brassicaeae* (*Cardamine*/*Descurania*), and *Polygonaceae*/*Cyperaceae*. These taxa are found in wide-ranging environments, although again, weeds that thrive in disturbed or arable soils were represented by *Chenopodium* and *Cardamine*/*Descurania* remains (Tison & de Foucault, 2014). Additionally, taxa often associated with ruderal and grass land may represent weeds of pasture, including *Bromus* sp., the most abundant weed with 13 examples, and *Ranunculus* sp. Broadly, the weed macrofossils from Layer B are typical of anthropogenically managed landscapes and support the involvement of Trou Arnaud within the agropastoral economy, albeit limited knowledge can be obtained from so few remains. Although, it is interesting that the only specimen of *Chenopodium album*, preferring fertile soils, was recovered from J4-K4b alongside high frequencies of nitrogen fixing legumes, perhaps indicating the impact of legume cultivation in an area with poor soils. Overall, the assemblage from Layer B suggests the presence of disturbed, arable soils and pasture proximal to Trou Arnaud, aligning with the conclusions drawn from palynological analyses by Argant et al (1996). The occupants were likely involved in the cultivation of crops and rearing of livestock throughout the phases related to Layers E and B, suggesting subsistence strategies relied on domesticated food sources throughout the cave's occupation. Although, the scarcity and broad growing conditions of the agropastoral weeds means inferences cannot be made regarding specific agricultural practices, including seasonality, harvesting technology or crop processing strategy. However, a summer occupation could be tentatively suggested due to the flowering times of *Rumex acetosella* (May to September, with similar summer flowering among most *Rumex* species) and *Chenopodium album* (seeds ripening throughout the summer), plus the improbable viability of winter cereal growth at mid-altitude (Williams, 1963; Escarre & Thompson, 1991).

However, it is notable that fewer ruderal remains were recovered than one might expect from a cave whose primary function was pastoral; comparatively, in the Final Neolithic layers at Grande Rivoire, apophytes are represented by 299 seeds, while 98 cereal macrofossils (grains and chaff) were recovered (Martin et al., 2008). Furthermore, cereal grains were overrepresented at Trou Arnaud, while remains of straw or crop processing waste, often used as fodder, were scarce. While this is almost certainly due to these smaller remains being lost during sample processing, we can still make some inferences regarding Trou Arnaud's role in the agropastoral economy.

Beeching (1981; 2003; et al., 2004; et al., 2005) proposed a model for the Chasséen agropastoral economy of the MRV, in which caves played an integral pastoral role. It was hypothesised crop cultivation was small scale and performed exclusively on the plains under sparse, managed tree cover, proximal to permanent lowland settlement and alongside cattle rearing. Adjacently in the Prealps, caves and rock shelters held a specialist role in the birthing and rearing of ovicaprids, suggesting a functional partition of Chasséen sites (Beeching et al., 2005). Weeds of pasture are often well-represented at sheepfold caves, preserved through burning of fodder and litter waste, animal dung, and trampling into occupation floors (Angelucci et al, 2009). An assemblage characteristic of caves within this model was well-illustrated by abundant dung layers at Grande Rivoire, comprising a high density of leafy branches used as fodder, ruderal weed seeds, wild plants with veterinary properties, and limited cereals, and to a degree at Les Balmes, although cereals were more abundant (Martin, 2014). Trou Arnaud does not fit perfectly into this model, in which evidence for dung layers, ruderal weeds and wild taxa are minimal, while cereal grains are abundant (Daumas & Laudet, 2012).

Additionally, the dichotomy between lowland and mountain sites during the Middle Neolithic is no longer considered to be so clear. The heterogeneity of botanical and faunal assemblages on mountain sites implicates a less prescriptive exploitation of altitudinal zones in the western Alps. Diverse site functions have been interpreted for mid-mountain sites including hunting camps, such as l'Aulp du Seuil where wild plant and animal remains dominate, open-air settlements as at Les Chenet des Pierres dominated by cereals, sheepfolds like Grande Rivoire, and sites with more enigmatic or multiple agropastoral functions such as Trou Arnaud and Les Balmes (Martin, 2014; Martin et al., 2019). Furthermore, suggestions of crop cultivation at altitude from both open-air and cave sites, including Les Balmes and Les Chenet des Pierres, suggest a more prolonged, or even permanent, occupation of the mid-mountain zones than argued by Beeching (Martin, 2014). This suggests a more complex organisation of the Chasséen economy in which cultivation was not limited to the plains, and agropastoral systems were not organised exclusively according to altitudinal zones. Although faunal remains indicate cave sites were closely tied to the birthing and penning of ovicaprids, often yielding concentrations of young sheep/goat remains, this role was perhaps not exclusive and within the context of a more consistently inhabited Prealpine landscape (Bréhard et al., 2010). Rather than altitude, specialist roles may have been linked to specific sites or groups, allowing a prolonged occupation of the mountain environment, and resulting in the diversity of archaeobotanical material from mid-mountain sites (Martin et al., 2019). Analysis of botanical and faunal data from the Neolithic Pyrenean landscape generated comparable conclusions, in which agropastoral strategies were similar between mountain and lowland sites, both reflecting medium to long term occupation through clear evidence for local crop cultivation, diverse livestock breeding and crop storage facilities (Antolin et al., 2018). It is likely the organisation of the Chasséen agropastoral economy was similarly nuanced in the western Alps. Even without considering the poor recovery of weed remains due to sampling limitations, the abundance of stored crops at Trou Arnaud, particularly of hardy varieties suited to a mountain cultivation, supports a prolonged habitation of the Diois Prealps beyond what is expected of a purely pastoral site.

Evidence of crop processing in the form of glume bases was limited at Trou Arnaud; this is clearly biased by the sieving of samples, thus it is impossible to infer how hulled cereals may have been stored. However, the abundance of cereals alongside the significant quantity of ceramic vessels suggests their storage within the cave. The storage of hulled wheats in spikelets was most common during the Neolithic and Bronze Age; it is usually hypothesised that pounding and winnowing occurred in the fields, while dehusking was performed daily on site, with the parching process providing opportunity for charring (Peña-Chocarro & Zapata, 2003; Bouby et al., 2005). This hypothesis aligns with much Chasséen botanical data, including at the Middle/Late Neolithic sites of Les Balmes and Les Bagnoles in which caryopses and glume bases are both recovered in significant numbers (Martin, 2014; Jesus et al., 2020). Storage of wheats within their husks is beneficial for long term storage, shielding caryopses from damp, fungi, insects, and rodents (Bouby et al., 2005). Nevertheless, it is also possible that crops were stored in a clean and dehusked state, having been fully processed in the fields immediately after harvest or beyond the confines of Trou Arnaud. Although storage of dehusked grains would seem impractical considering the humidity of the cave, their smaller weight and volume, occupying less than half the space of husked grains, may have been a logistical choice, aiding transportation across the difficult terrain leading to the cave (Alonso et al., 2013). The scarcity of glume base remains would support this explanation, however this data is unreliable due to the sample processing methodologies employed. Additionally, the recovery of 15 saddle quern fragments attests to some processing of grains; these may have played a role in dehusking, although they could also be related only to the grinding of cleaned grain.

It is clear discussion is hindered by the limited recovery of macrofossils beyond cereal and legume grains. The scarcity of smaller remains suggests methodological limitations, of unknown sampling strategy and coarse sieved processing methodologies, contributed to the near absence of arable or ruderal weeds and chaff, although the influence of archaeological crop processing and storage practices cannot be completely ruled out. Nevertheless, it can be suggested that Trou Arnaud was closely connected to the agropastoral economy of the Diois; crops were likely locally cultivated although the dynamic between sites in the Prealpine mountains and the plains of the MRV remains unclear and more nuanced than previously suggested.

5.3. The situation of Trou-Arnaud within the Alpine landscape: the character and exploitation of the environs

It is challenging to construct an understanding of the environment surrounding Trou Arnaud due to the scarcity of macrofossils from wild taxa. Therefore, the few remains identified have been considered alongside earlier charcoal analyses and palynological data from the structure in I3/4 to generate a narrative regarding the surrounding vegetation and its exploitation by early farmers (Argant et al., 1996; Daumas & Laudet, 2012). It is assumed the charcoal reflects surrounding vegetation, represented by local woods gathered for domestic purposes, likely as fuel. Overall, a widespread picture of deforestation for pasture and arable land in the Diois was suggested throughout the Chasséen, in which vegetation from numerous mountain stages were exploited for agricultural or domestic functions.

While the earliest phase of occupation in Layer G (c.4460 BC) was represented near exclusively by charcoal from montane species (*Pinus sylvestris*, *Abies alba*, *Taxus baccata*, *Juniperus* sp.), by Layer E (c.4361 BC) taxa from the collinean stages (*Quercus* sp., *Acer* sp.) and riparian flora (*Salix populus*, *Fraxinus excelsior*) increased in significance to 26% and 25% of the charcoal respectively (Daumas & Laudet, 2012). These species are typical of humid mid-European climate, while the diminishment of conifers suggests a transition towards a more open landscape (Argant et al., 1991). Macrofossils from wild taxa are extremely limited in layer E, however the presence of agropastoral weeds (*Rumex acetosella* and *Galium* sp.) alongside abundant crops attests to the exploitation and disturbance by farmers upon the local environment. The abundance of pollen from ruderal species, particularly *Plantago*, in the outer fabric of the clay structure attributed to Layer E further supports this (Argant et al., 1996). The botanical data altogether indicates towards the first intensive anthropogenic changes to the landscape occurring by Layer E; coniferous montane forests persisted throughout Layers G and E, although declined following clearance for pasture and agriculture, resulting in an increase of light-demanding flora of disturbed soils and mixed forest.

Montane species are almost entirely absent by Layer C (undated), in which collinean species dominate with *Quercus* sp. comprising 73% of charcoal (Daumas & Laudet, 2012). By Layer B (c.4197 BC), collinean species equate to 55% of the assemblage, while riparian flora represents 41% of material. However, the anthracological samples were collected from a single hearth for both Layers C and B, thus may not be representative of the entire phase. It was suggested the riparian charcoal was likely overrepresented due to the use of *Cornus sanguinea* as fuel rather than its predominance in the landscape (Daumas & Laudet, 2012). Nevertheless, the overall trend suggests continuing mountain deforestation to clear for pasture and arable lands. Similar conclusions were reached based on pollen within Chasséen levels at Antonnaire, in which ruderals, sedges, and light-demanding trees gained importance after 4000 BC (Argant et al., 1991). Additionally, mirroring the anthracological data, macrofossils from Trou Arnaud reflect the exploitation of multiple vegetation stages and environmental conditions. These could be found local to the site, including riparian flora (*Fraxinus* cf. *excelsior*, *Carex* sp.) present along the Volvent stream in the valley below Trou Arnaud, agropastoral fields attested by ruderal and arable weeds, hedgerows (*Rubus* sp.) and deciduous, coniferous or mixed forests at varying altitudes characterised by collinean (cf. *Quercus* sp.) and montane taxa (*Abies* sp. and a possible example of cf. *Juniperus*).

Local trees were likely collected for use as firewood, notably *Quercus* and *Cornus*. Trees that thrive on the calcareous soils of the Diois Prealps were macrobotanically represented by one instance of a cf. *Quercus* bud – in which *Q. pubescens* is the most represented charcoal - and a fragment of a *Fraxinus* cf. *excelsior* key. Both are early succession species following boreal disturbance, such as clearance for grazing, and characteristic of open woodland, thus may represent trees bordering pasture, accessible to the occupants of Trou Arnaud (Dobrowolska et al., 2011). Interestingly, *Abies* is rare in the anthracological record, only appearing in Layer E, and in the undated pollen data (Argant et al., 1996; Daumas & Laudet, 2012). Albeit scarce, carbonised needle leaf fragments appear in three contexts at Trou Arnaud, most abundantly in I4b. The representation of *Abies*, in which *Abies alba* grows up to 1900 m altitude in the southern Alps, suggests some montane forest persisted, and groups travelled to higher altitudes to collect plant resources (Tison & de Foucault, 2014). Furthermore, *Abies* is a poor fuel, producing much smoke; when considering the underrepresentation of conifers in the anthracological assemblage of Layer B, the presence of leaf fragments may implicate the collection of young branches rather than mature firewood (Proszak-Miasik & Rabczak, 2019). This reflects practices at Grande Rivoire, in which young conifer branches played a role in livestock management, perhaps used as litter due to their softness and the antibacterial properties of young buds (Martin, 2014). Additionally, *Abies* leaf foddering was practiced across the Alpine Neolithic to supplement the diet of flocks, attested at Grande Rivoire, Les Balmes, and particularly across the Swiss Alps, including the lower altitude site of Arbon Bleiche 3 (Akaret et al., 1999; Martin et al., 2008; Martin, 2014). The remains from Trou Arnaud are too sparse to generate any concrete conclusions, however, its role in livestock management remains a possibility.

It is also likely wild plants were gathered to supplement farmer's diets, based mostly on domesticated crops and livestock. However, many foraged food plants, such as berries, may be eaten raw or do not require extensive processing prior to consumption, thus their preservation via charring is less likely than cereal crops. Gathered plants that preserve best archaeologically are biased towards species concentrated in woodlands, woodland edges, and hedgerows, especially fruit and nut bearing trees or berry producing shrubs, while plants consumed as leaves may be preserved less frequently (College & Connoly, 2014). Hedgerows local to Trou Arnaud are attested by two examples of *Rubus* sp. (probably *R. idaeus* or *R. fruticosus agg.*) surrounding the hearths of J4-K4, likely attributed to Layer B. Their recovery from a domestic context linked to food preparation suggests these were gathered for human consumption, although their deposition from burned dung is also plausible, in which livestock browsed hedgerows bordering pasture. The gathering of wild food sources was also suggested by the pollen data from I3/4, despite the absence of undomesticated macrofossils from these contexts. High levels of *Chenopodium*, *Plantago*, and *Polygonum* were detected in the inner walls of the clay structure, suggesting the vessel was used to store plants foraged from agropastoral environments, alongside some cereals (Argant et al., 1996). One macrofossil of *Chenopodium* cf. *album* was also recovered from a hearth context. Historically, *Chenopodium album* has been used as salad, comparable to spinach today, and cultivated as a pseudo-cereal, similar to the modern consumption of *Chenopodium quinoa* on Linear pottery sites in Early Neolithic Poland (Mueller-Bieniek et al., 2018; 2019). Also, *Polygonum* seeds acted as a condiment in the Bronze Age around Neuchâtel (Jacquat, 1989). Argant et al. (1996) suggested the clay vessel was used to store leaves for stews, salads, and porridges, with leaves either mixed or arranged in layers. Leaf imprints in the clay may also indicate their use in lining the vessel to prevent contents from sticking to the sides, displaying the diverse roles of wild plants in food preparation. The production of sauerkraut using foraged leaves was also hypothesised, however no chemical trace of fermentation was detected in the clay walls (Argant et al., 1996). Overall, it appears likely wild plants, opportunistically gathered from the surrounding landscape, supplemented the diets of farmers at Trou Arnaud, although the breadth of taxa exploited, and their importance is difficult to interpret due to the limited preservation of macrofossils.

5.4. Chasséen occupation of Trou-Arnaud

Broad inferences have been made regarding lifeways at Trou Arnaud, including the important, and likely varied, role of plants within the lives of early farmers; crops were plausibly cultivated in the mid-mountain environs of the cave, and the local environment exploited for arable land and pasture, wild food resources, and fuel. Subsequently, discussions into the character of occupation at Trou Arnaud can be examined, to reassess the function of an enigmatic space, unusually abundant in crops and ceramics, and more widely highlight the nuanced use of caves within Chasséen agropastoral society.

5.4.1. Diet of the first farmers in the Diois

The diet of farmers at Trou Arnaud was likely typical of the MRV during the Neolithic. This comprised a diverse range of staple crops, including numerous varieties of cereal grains and legumes, meat proteins mostly from livestock reared close to the site, while hunted and gathered food sources were supplementary. No exotic food plants or fauna were identified, suggesting a locally-sourced, but diverse diet.

Some dietary dependence on cereals is implied through unusually abundant grain stocks in storage areas and the cultivation of reliable varieties adapted to the Diois landscape; a comparable situation was interpreted at Les Balmes (Martin, 2014). It is plausible the diverse culinary properties of cereals contributed towards their consumption in numerous dishes; today *Hordeum vulgare* is more common in porridges and stews, while wheats are popular also in breads (Kreuz, 2020). Grains likely comprised the majority of daily calorie intake. A dependence on plant resources was similarly indicated through carbon and nitrogen stable isotope analysis on human remains from 21 sites across Neolithic Switzerland; terrestrial plants, assumed to relate mostly to crops, were significant dietary contributors to all studied groups, while the importance of meats varied, attributable to cultural influences (Siebke et al., 2020).

The high representation of legumes is also notable at Trou Arnaud, represented by 400 examples of *Pisum sativum* or *Lens culinaris*. This abundance may reflect a dependence on plant-based protein sources, particularly if animal protein consumption is decreased, for example if animal stocks were depleted or for cultural preference. Lowered meat consumption was identified in Eastern Switzerland based on low Nitrogen isotopic values in human remains, interpreted as reflecting cultural influences on diet; meanwhile increases in butchered wild fauna during the Late Neolithic on the Plateau suggest climatological degradation coincided with decreasing livestock numbers (Schibler & Jacomet, 2010; Siebke et al., 2020). However, in Languedoc, an increased reliance on plant proteins was argued as a culinary reflection of Chasséen social hierarchies (Le Bras-Goude et al., 2013). Individuals buried in reused silos or in funerary pits relied on higher amounts of vegetal protein than individuals in lithic chambers, indicating dietary differentiation based on social status or expressions of religious worship (Le Bras-Goude et al., 2013). Although the quantity of legumes at Trou Arnaud suggests some reliance on plant proteins, it is not possible to understand the normalcy of this in the western Alps as *Fabaceae* remains are rarely preserved. Although considering the interpretation that livestock stabling was small-scale at Trou Arnaud, it is plausible legume proteins were considered essential dietary contributors (Daumas & Laudet, 2012).

The abundance of domesticated subsistence resources and limited reliance on wild foods suggests that despite its relative isolation, Trou Arnaud was incorporated in, and typical of Chasséen agropastoral economies. While crop remains comprised 99% of the identified macrofossil assemblage, probably representing the primary source of plant nutrition, the storage of wild plants is known from the palynological analysis of I3/4 (Argant et al., 1996). Wild flora growing near to the cave may have been gathered as supplements, adding culinary variety, and acting as condiments. However, understanding of their importance is hindered by their limited representation, perhaps attributable to the unrecorded sampling and processing methodologies. Furthermore, taphonomic processes on dry sites, mainly opportunities for and survival through charring, may have resulted in an underestimation of the significance of gathered plants in the southern and western Alps. Conversely, wild plant resources were significant in Middle-Late Neolithic diets on the northern lake settlements, notably dominating the macrofossil corpus at Parkhaus Opera (Zurich) (Antolin, et al., 2020).

This predominance of domesticated resources is mirrored in the faunal assemblage assessed by D. Helmer, in which wild fauna, mostly represented by deer, comprises only 6% of the animal remains (Daumas & Laudet, 2012). Sheep or goats likely formed the main source of animal protein, at 76% of the animal remains, alongside some limited contribution by cattle and pigs (Daumas & Laudet, 2012). This reflects Beeching's (1981; 2003; et al., 2004; et al., 2005) suggestion Prealpine cave sites were specialised towards the rearing of ovicaprids, better suited to mountain stabling than cattle, moving well over tough terrain, able to browse on coarse shrubbery, and causing less erosion to shallow soils. Their pasturing at altitude facilitates the exploitation of a less-economically viable and difficult to cultivate landscape. Although livestock stabling was suggested to be small-scale at Trou Arnaud, small herds may have been reared for the consumption by farmers without the generation of substantial surplus, suggesting adaptability to mountain environments was considered in both plant and livestock subsistence management (Daumas & Laudet, 2012).

5.4.2. Proposed site function and role in the Chasséen agropastoral economy

Although the primary function of Trou Arnaud has remained enigmatic, new perspectives on the archaeobotanical material and comparison with broader Alpine prehistoric cave use have been assessed to consider its role. Consequently, it is hoped a more comprehensive picture of the Chasséen organisation of the Alpine landscape can be achieved. The results of macrofossil analysis were used to critique suggestions for site function proposed by Daumas & Laudet (2012) to conclude that Trou Arnaud was likely a temporarily occupied, multifunctional space, with a partially pastoral role.

Beeching (in Daumas & Laudet, 2012) remarked that the cave saw repeated, but brief phases of occupation. This interpretation was founded upon the lack of structural modifications to the cave, limited to the clay storage structures, the transient character of hearths, small lithic assemblage, and the minor levels of sedimentary disturbance, suggesting minimal trampling by human occupants and livestock. Furthermore, the cave provides a cold and humid environment, argued to be uncomfortable for long periods of habitation. This interpretation was difficult to assess from an archaeobotanical perspective; the weed assemblage was too small to establish the seasonality of crop and pasture use, thus no relationship to the season or duration of occupation could be discerned. Nevertheless, the possible storage of dehusked grains supports a temporary occupation. Grains are generally stored in bulk to ensure a group's food supplies for the short or long term, or to store seeds for the next harvest (Prats et al., 2020). However, dehusked glume wheats would not preserve well in the humidity of the cave, likely to spoil or germinate relatively quickly, suggesting the grains were intended for short-term consumption. Even so, one must consider the taphonomic bias against spikelet remains in charred assemblages, particularly if burnt under high temperatures, and their likely underrepresentation due to the use of coarse sieves during sample processing, thus the storage of dehusked cereals at Trou Arnaud is uncertain (Bouby et al., 2005).

A fleeting occupation may also suggest the crops were less likely to have been grown in the immediate environs of the cave, instead suggesting close ties with a nearby permanent open-air settlement. The adaptation of the chosen crop varieties to a mountain climate is unsurprising nevertheless, considering the harsh character of the Diois climate and soils may have necessitated hardier crops even at lower altitudes in valleys local to the cave. Their suitability to broad environmental conditions means their attribution to the occupants of the cave or of a nearby settlement are impossible to discern. However, temporary occupation can range from fleeting visits to the course of a season in which cereal growth is plausible. The possibility remains of a seasonal occupation, likely summer, by a small agropastoral group with a limited amount of livestock, which may present a similar crop assemblage and sedimentary disturbance to more fleeting occupation by lowland groups who transported crops.

Prealpine caves were often associated with pastoral roles during the Chasséen for the stabling and birthing of ovicaprids, however Daumas & Laudet (2012) argued the use of Trou Arnaud as a sheepfold was secondary (Brochier et al., 1999). Numerous archaeological characteristics are typically expected of sheepfold caves from the Neolithic to the Iron Age; these are an abundance of spherulites, phytoliths, pastoral weed seeds, and silty sedimentation, while grains are occasional and material culture is sparse (Angelucci et al., 2009). Gathered flora relating to livestock management may also be recovered; at Grande Rivoire, *Taxus baccata* and *Abies alba* needles are interpreted as litter or leaf fodder, while *Viscum album* was possibly used to encourage lactation in ewes (Martin et al., 2008). Notably the material at Trou Arnaud contrasts this, featuring an abundance of ceramic and crop remains while phytoliths relating to animal dung or spherulites were sparse in microscopically analysed sediment (Daumas & Laudet, 2012). Nevertheless, the identification of pastoral caves is more nuanced than the criteria proposed by Angelucci et al. (2009). For example, although cereals were scarce, material culture and hearth remains were abundant in the Chasséen-St Uze layers at Gardon cave, interpreted as a high occupation intensity sheepfold, although semi-permanently or permanently occupied (Perrin et al., 2003; Voruz et al., 2004). Additionally, the cereal assemblage at Trou Arnaud is comparable to the sheepfold-dwelling of Les Balmes, housing a community unit and small number of livestock, interpreted based on sedimentological analyses and the recovery of *Abies* branches used for littering, despite grains being recovered in abundance (Martin, 2014). A similar arrangement is plausible at Trou Arnaud on a smaller scale, with grains cultivated nearby or at a neighbouring permanent settlement. Furthermore, despite the dissimilarities with botanical material from sheepfold caves such as Gardon or Grande Rivoire, the faunal assemblage aligns with the model for the Chasséen agropastoral economy in which caves were specialised birthing areas for caprines (Blaise, et al., 2010; Bréhard, 2011). 68% of caprine remains at Trou Arnaud derived from animals under 2 months old, consistent with a birthing area function, while *Abies* needles, frequently used in littering, were recovered in small amounts, perhaps underrepresented due to the loss of fragile remains during processing (Daumas & Laudet, 2012). Regarding the sparsity of spherulites, the locations sampled for sedimentological analyses were not documented; however, their underrepresentation is unsurprising if only the most recently excavated area, the domestic area by the cave entrance, was sampled. Brochier et al. (1999) noted livestock were generally housed deeper within the galleries, in zones less suited to domestic activities requiring light; consequently, sediment from deeper areas such as the Galerie des Pots may present a different picture. Overall, the variability in botanical and material assemblages from caves interpreted as sheepfolds, alongside the possibility of material unrepresented by sampling or lost during processing means a pastoral role is plausible for Trou Arnaud, either as a primary or joint function.

While holding at least a partially pastoral role, the character of occupation at Trou Arnaud was likely more nuanced and multifaceted. A multifunctional cave site is attested at Le Grotte de Pertus II (Alpes-de-Haute-Provence), originally a sheepfold cave, that developed joint roles as a ceramic studio and dwelling site by the Recent Chasséen (Battentier et al., 2016). Thus, alternative functions for Trou Arnaud, requiring a general occupation for short periods of time, must be considered. The interpretation preferred by Daumas & Laudet (2012) was that of a refuge or resource gathering base associated with a local permanent settlement. The suggestion of a refuge during disturbed periods was founded on the concealed, difficultly accessed location of the cave entrance and the abundance of ceramics and grains. While caves interpreted as sheepfolds are usually easily approachable with a large area for livestock, refuges are less accessible, with a greater area dedicated to human occupation and smaller stabling areas (Vital et al., 1987). Trou Arnaud aligns well with this suggestion, featuring a small entrance set within the cliff face of a steep gorge, and the Galerie des Pots interpreted as a large domestic storage area. Caves interpreted as refuges with similar botanical assemblages have been identified in the Bronze Age. Dehusked glume wheats were also noted at the Bronze Age refuge cave of Balme Layrou (Gard), attributed to the reduction of grain weight and volume to ease transportation across the difficult terrain (Bouby et al., 2005). A diverse ceramic corpus and abundant cereal stocks were also recovered at La Balme à Gontran (Ain), argued to be a refuge due to the challenge of transporting large vessels and grain stores to a remote and concealed site, suggesting their movement was extremely necessary (Treffort et al., 1999). Similar conclusions could be reached regarding Trou Arnaud, particularly since the majority of material culture and grains related to one phase (Layer B), indicating an intensification of occupation perhaps related to a broadening of roles, possibly during a socioeconomically tumultuous time.

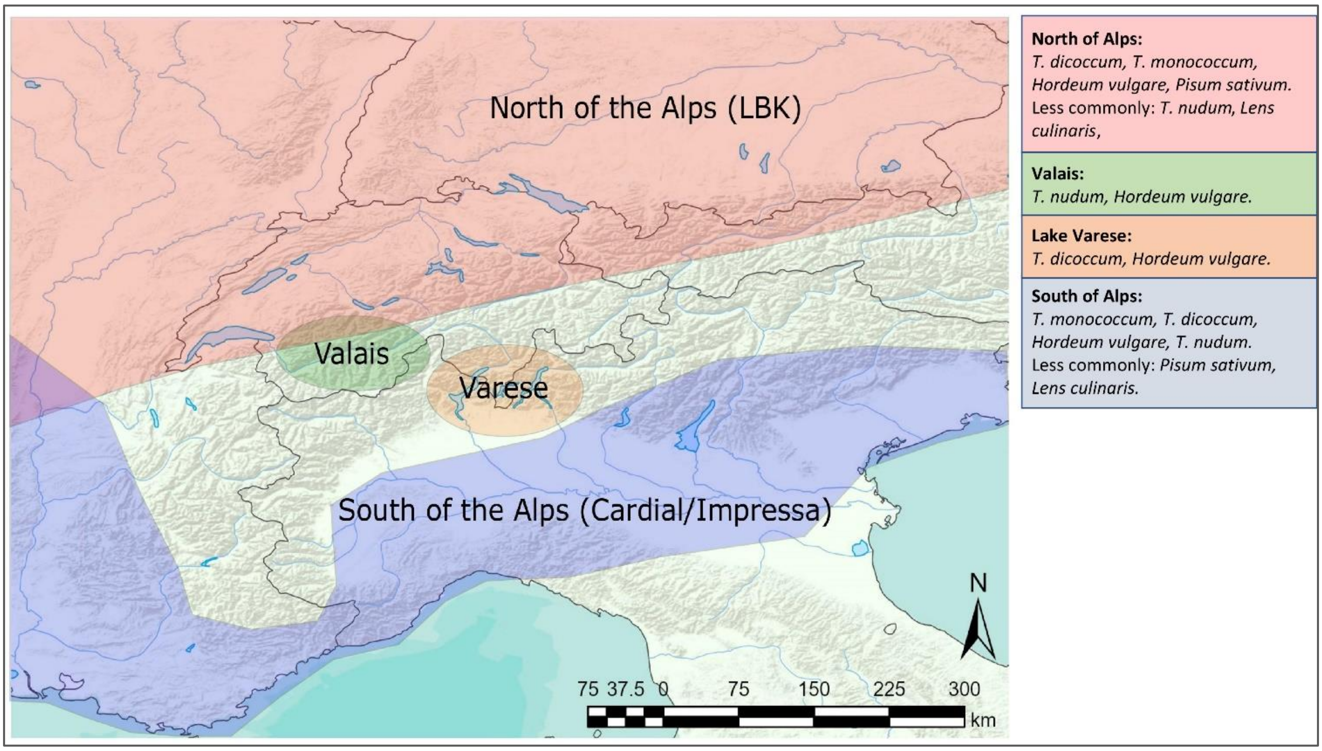
Use as a base for resource gathering was also suggested due to the fleeting character of occupation (Daumas & Laudet, 2012). A hunting camp is unlikely since faunal remains from wild animals were extremely limited; the subsistence remains also contrast those at the hunting stop of L'Aulp du Seuil in which grains were rare and wild fauna was prevalent (Martin et al., 2012). The cave's placement in the western Prealps, a focal area of the Alpine flint exchange circuit, may justify its consideration as a rock resource gathering base or base along a route into or across the Alps, however this is not supported by the limited lithic corpus, or the heavy abundance of grains and ceramics, unlikely to be carried by travellers (Della Cassa, 2005; Daumas & Laudet, 2012). A camp for the collection of water, clay or other local resources remains a possible function.

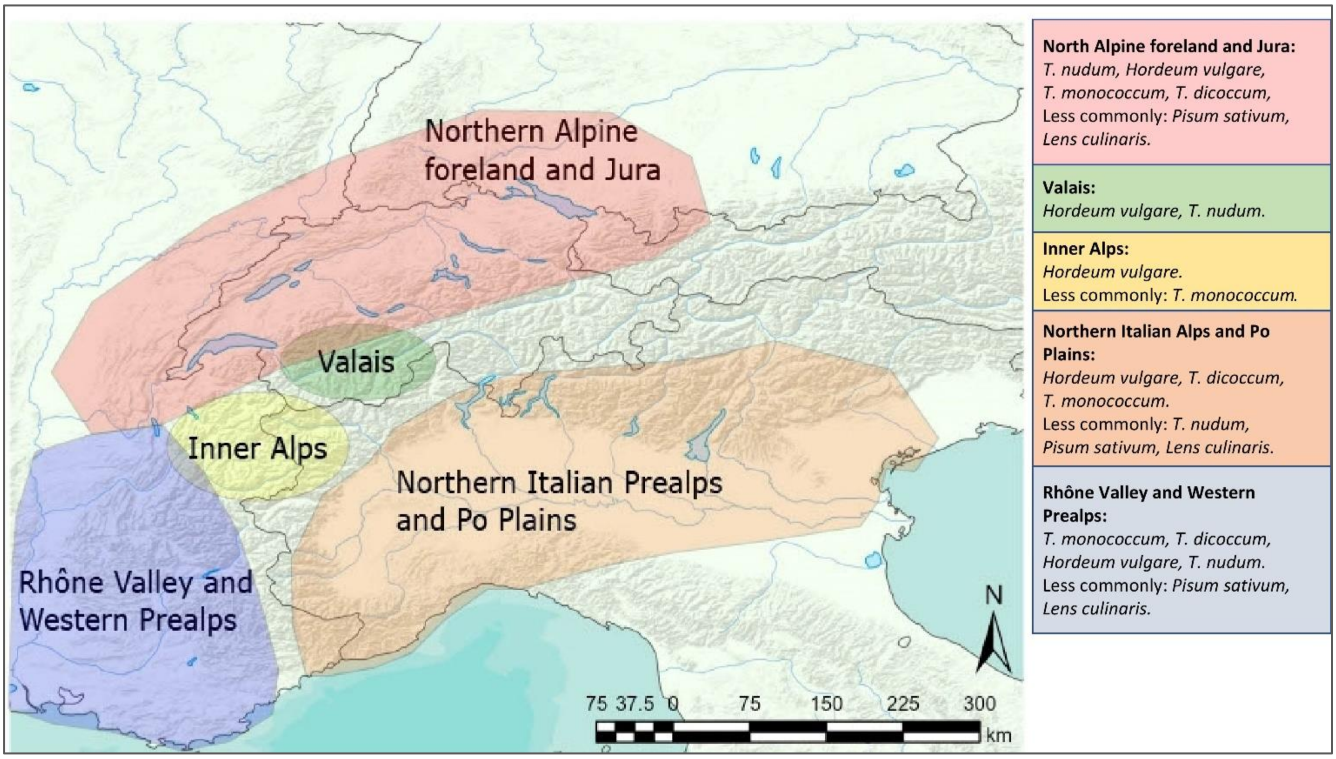
Notwithstanding the enigmatic and likely multifaceted function of Trou Arnaud, the adaptation of crops to the environmental niche of the Diois, and abundance of grains, including in hearth deposits, suggests some occupation by local farmers. The cave was temporarily occupied and held a partially pastoral function. Its joint role as a resource gathering base or refuge is not inconceivable; a cave already known to a group through its pastoral use would be a reasonable choice for refuge during emergencies. Nevertheless, the cave of Trou Arnaud was ingrained within the Chasséen agropastoral economy, used in the management of livestock and storage of grains, although these practices were modified towards the marginal landscape. Crops were plausibly grown around the cave, but their cultivation in nearby valleys is also possible, while the site was almost certainly tied to a nearby more permanently occupied settlement.

6. Conclusions

This work aimed to explore the complexity of specific cultural and environmental factors that influenced Neolithic farming by assessing variation in agricultural practices around the western Alps. The primary source of evidence was archaeobotanical material that informs inferences regarding staple crop assemblages. An analysis of plant macrofossils from Trou Arnaud was presented as a case study to examine the role of caves within the Chasséen agropastoral economy, better understand the character of crop cultivation in the Prealpine landscape and provide an example of the adaptation of agricultural practices in marginal environments. It was concluded that the Alpine environment and topography, in combination with cultural and climatic factors, influenced core crop choice in two aspects: by influencing the movement of people and spread of agricultural ideas, and through the constraints on cultivation conditions within Alpine environmental niches.

The Alps were not a complete barrier to the movement of people and ideas during the Neolithic. This is attested by the recovery of artefacts in the inner valleys and evidence for long-distance material exchange networks centred around Alpine flint sources (Ricq-de Bouard & Fedele, 1993; Hafner & Schwörer, 2017). Nevertheless, the character of cultural spheres on either side of the Alps differs distinctly, reflected both in material culture and in the crop assemblages. Crop preferences consistently differ between groups on and around the northern Prealpine lakes, in the Rhône Valley to the west, and in northern Italy, throughout the Neolithic (see figure 26). This is particularly notable during the Early Neolithic in which crop preferences are distinct between north and south of the Alps, reflecting the Mediterranean and Danubian routes of Neolithisation, and during the Middle Neolithic 2 to Late Neolithic in which free-threshing wheats are popular in the northern Prealps, while glume wheats dominate the south and west. The Rhône Valley was also highlighted as a key route into the Alps, in which inner Alpine crop assemblages are often most similar to those from the western plains, albeit with higher proportions of *Hordeum vulgare* and glume wheats on mid-high altitude sites, more resilient within the harsher climate. Overall, this suggests groups were culturally divided by the extreme topography of the Alpine ranges, although using the passes as routes into and through the mountains, reflected in differing agricultural strategies, crop preferences, and material culture either side of the Alps.


North of the Alps (LBK)
Valais
Varese
South of the Alps (Cardial/Impressa)
N
75 37.5 0 75 150 225 300
km
North of Alps:
T. dicoccum, T. monococcum, Hordeum vulgare, Pisum sativum.
Less commonly: T. nudum, Lens culinaris,
Valais:
T. nudum, Hordeum vulgare.
Lake Varese:
T. dicoccum, Hordeum vulgare.
South of Alps:
T. monococcum, T. dicoccum, Hordeum vulgare, T. nudum.
Less commonly: Pisum sativum, Lens culinaris.


Northern Alpine foreland and Jura
Valais
Inner Alps
Northern Italian Prealps and Po Plains
Rhône Valley and Western Prealps
N
75 37.5 0 75 150 225 300
km
North Alpine foreland and Jura:
T. nudum, Hordeum vulgare, T. monococcum, T. dicoccum,
Less commonly: Pisum sativum, Lens culinaris.
Valais:
Hordeum vulgare, T. nudum.
Inner Alps:
Hordeum vulgare.
Less commonly: T. monococcum.
Northern Italian Alps and Po Plains:
Hordeum vulgare, T. dicoccum, T. monococcum.
Less commonly: T. nudum, Pisum sativum, Lens culinaris.
Rhône Valley and Western Prealps:
T. monococcum, T. dicoccum, Hordeum vulgare, T. nudum.
Less commonly: Pisum sativum, Lens culinaris.

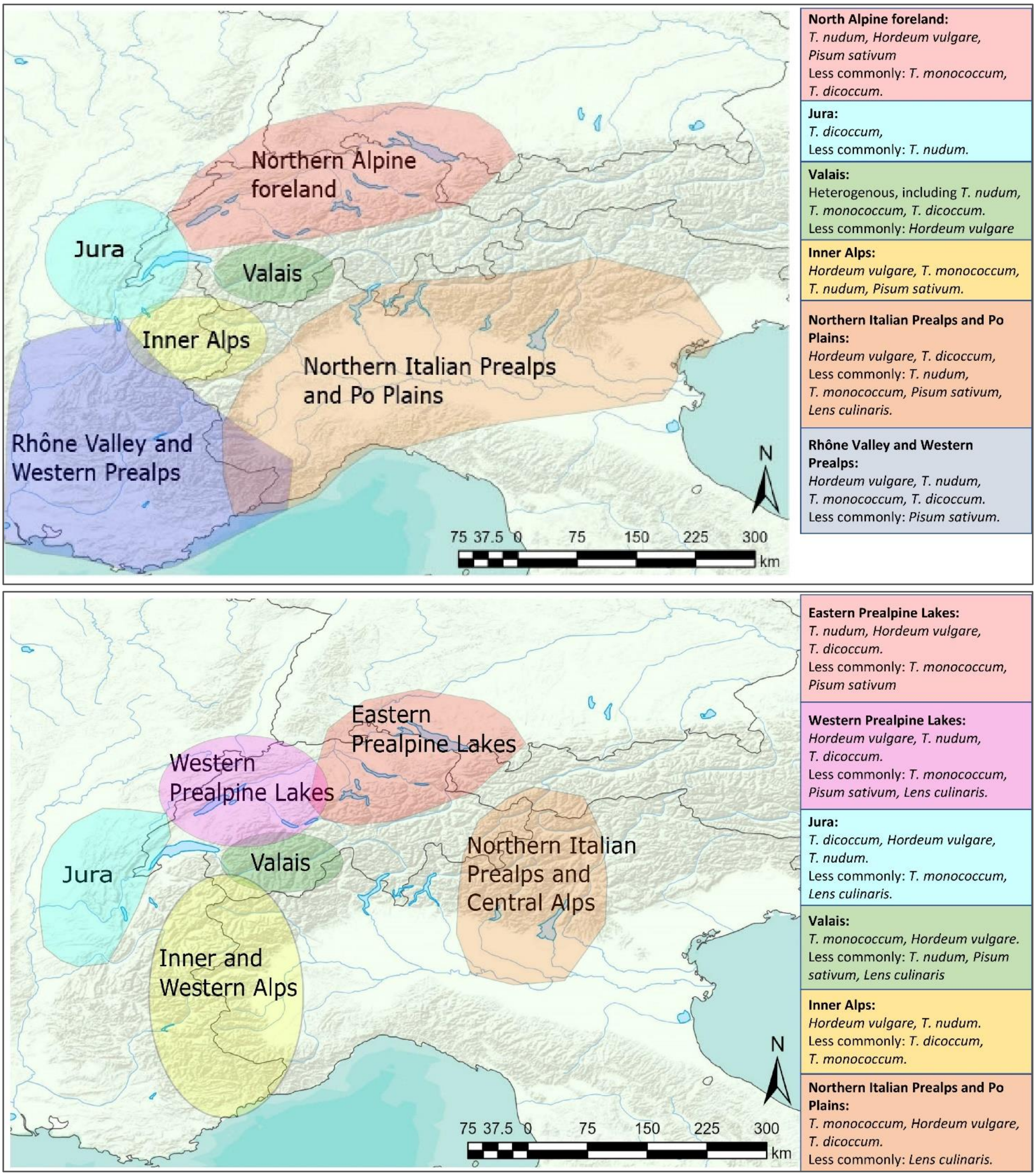


FIGURE 26. MAPS DEPICTING REGIONAL CROP PACKAGES AROUND THE ALPS THROUGHOUT THE NEOLITHIC. NOTABLY, CROP PACKAGES ARE DISTINCT EITHER SIDE OF THE ALPS AND IN PARTICULARLY ISOLATED REGIONS, I.E. VALAIS.

Altitude and environmental conditions, including soil conditions, also affected agropastoral practices during the Neolithic. Hardier crops were better represented than less reliable free-threshing wheats on higher altitude sites or areas of impoverished soil and harsher climate; notably, *Hordeum vulgare* often dominated assemblages from internal Alpine sites, while glume wheats were especially popular in the Prealps of Drôme from the Middle Neolithic 1. Although it is not certain that these crops were cultivated at altitude, the consistent popularity of crops that were better adapted to frosts, extreme weather, unpredictable precipitation, or shallow nutrient-poor soils, typical of mountain environments, supports the plausibility of their growth in mid-mountain zones. Consequently, it was concluded that agricultural strategies were adapted to increase the reliability of yields under marginal environmental conditions, resulting in the varying character of Alpine crop assemblages throughout the Neolithic.

The assemblage from Trou Arnaud provided an excellent example of this. Cultural similarities with the plains of the Rhône Valley were attested by the abundance of Chasséen ceramics, typical across Southern France during the Middle Neolithic. The initial popularity of *Hordeum vulgare* was often dominant on Ancient Chasséen lowland sites. However, the preference towards glume wheats during the later occupation phase of Trou Arnaud was perhaps not entirely culturally influenced. The absence of free-threshing wheats was unusual on Chasséen sites before 4000 BC; thus the preference towards hardy glume wheats, *Hordeum vulgare,* and nitrogen-fixing legumes denote an adaptation of agricultural strategies to facilitate local cultivation on the poor soils of the Diois. It appears farming practices changed as groups settled the Diois more intensively; *Hordeum vulgare*, a particularly adaptable crop, was preferred initially; however, the crop assemblage diversified as the environment became more intimately understood and extensively exploited following intensified deforestation.

The role of Trou Arnaud within the Chasséen agropastoral economy was also assessed. The abundance of cereal and legume crops suggests their importance as a staple of the occupants' diets alongside livestock. Diet was supplemented with wild plant and animal resources. The occupants exploited the local environment for plant resources, while crops were plausibly cultivated relatively local to the site. However, the cave's primary function remains enigmatic; its integration into the Chasséen agropastoral economy as a sheepfold cave, used for the birthing of lambs, is probable, although the space was likely multifunctional, with a greater emphasis on temporary human habitation than on a purely pastoral site. Subsequently, this work has highlighted the need for more nuanced interpretations into Alpine agropastoralism during the Chasséen than previous models have proposed (Beeching, 1981; 2003; Beeching et al., 2004; 2005).

Although regional variation in animal husbandry has been recognised in zooarchaeological assemblages from western Europe, studies reached mostly broad continent-wide conclusions, while limited research focused on Alpine livestock preferences. Nevertheless, the results of these studies often mirrored regional differences in crop cultivation, denoting a significant environmental influence on subsistence. During the Early to Middle Neolithic, cattle was preferred in northern and western Europe while caprines dominated along the Mediterranean, reflecting the distinct crop packages north and south of the Alps associated with different currents of Neolithisation (Manning et al., 2013). Some evidence for the adaptation of husbandry practices to Alpine environments was also identified in southwestern France; while cattle dominated open-air sites in the Rhône Valley, smaller ruminants (sheep/goat) were prevalent on Prealpine cave sites and inner Alpine sites, such as Schnidejoch Pass, attesting to a preference in livestock based on geographical location and site type (Brehard et al., 2010; Hafner & Schwörer, 2017). Subsequently, an association between mid-high altitude sites, hardy crop cultivation, and ovicaprid husbandry - particularly birthing activity - appears characteristic of mountain agropastoralism. The abundance of *Hordeum vulgare*, glume wheats and remains of caprines under 2 months at Trou Arnaud provides a particularly convincing example of distinctive mountain agropastoral practices. Future work to synthesise broad scale archaeobotanical and zooarchaeological data may provide more holistic insight into the influence of Alpine environments and cultural identities on subsistence strategy.

Overall, this reassessment of the plant macrofossil assemblage from Trou Arnaud has generated a more comprehensive understanding of agricultural practices in the Diois. Its integration within the dataset of existing Alpine archaeobotanical data supports interpretations that the Prealpine landscape was farmed by the Middle Neolithic using specifically adapted agricultural practices, preferring hardier crops, to enable cultivation in mountain climates and soils. This development marks the beginning of more intensive anthropogenic impact upon a sensitive environment that continues to day. Today, some areas of the Alpine landscape are rapidly degenerated by contemporary agricultural practices and industry through the specialisation of farms, overexploitation of fertile land, and intensified pesticide usage, resulting in an uncertain future for regional farming and biodiversity (Fleury et al., 2008). These agricultural systems are threatened by climate change, in which hydrological changes, erosion, increased episodes of summer drought and winter flooding, and shifts in grassland ecology due to new migrating species are predicted in the Alps (von Glasenapp & Thornton, 2011). However, the persistence of traditional ecological knowledge has been identified as a key factor in the resilience and longevity of traditional alpine farming practices; this involves seasonal movement of livestock, labour intensive summers with flexible labour based in the community, and an intimate local environmental knowledge regarding the rugged terrain and extreme weather systems (von Glasenapp & Thornton, 2011). Traditional practices have been recognised as a vital tool for Alpine farmers in adapting to climate change, while future land management plans must be organised locally due to the intense variability within the Alpine landscape (Fleury et al., 2008).

Nevertheless, many modern farmers are disconnected from these practices due partly to the cultural value on productivity; von Glasenapp & Thornton (2011) suggested a cultural shift must occur to highlight the benefit of long-term resilience over short-term output and increase uptake of traditional practices. The long history of traditional Alpine farming can be highlighted through archaeological study, reinforcing notions of its adaptability and sustainability across millennia of environmental and climatological change. Archaeobotanical perspectives are especially relevant to exploring the human-environment relationship in the Alps, the impact of these interactions, and crop cultivation strategy informed by traditional knowledge. Therefore, it is hoped this work has contributed to a more holistic understanding of Alpine agricultural history, particularly within the Diois region.

Even so, understanding of early agropastoral activity in the Alps is still limited due to the relatively small number of detailed studies. Although adaptive strategies employed by Neolithic farmers in Alpine farming have been identified, the conclusions remain relatively broad: that farmers preferred hardier crops in marginal areas or periods of climatic stress. Future research should aim to develop these interpretations to a higher level of detail. This may include aDNA analysis on waterlogged or desiccated crop remains to explore variations in agricultural practices that are difficult to detect through traditional archaeobotanical morphometrics, such as the cultivation of different landraces or cultivars as an adaptive agricultural strategy or identifying genetic traits in ancient cultivars that are well suited to Alpine agriculture today (Brown et al., 2015; Wales & Kistler, 2019). More macrofossil data must also be generated from the Alpine landscape, including the re-examination of data from sites excavated during the 20th century prior to the identification of the ‘new glume wheat’, and the publishing and synthesis of morphometric data, reflective of different landrace morphologies, cultivation conditions, or taphonomy (Jones et al., 2000). A lack of macrofossil data from weed and wild taxa was also a limiting factor in this analysis, resulting from the use of coarse sieves during sample processing. Future sampling must be conducted using up to date processing methodologies to enable more robust interpretations into the altitude of cultivation, seasonality in agropastoral systems, harvesting methods, and further landscape exploitation. Nevertheless, this work has contributed towards developing a more robust knowledge regarding the role of crops during the

Alpine Neolithic. It is hoped in future, a more holistic understanding of Alpine landscape history can be generated to inform and inspire contemporary land management strategy with an aim towards agricultural systems becoming less damaging to Alpine soils and more resilient to the changing climatic conditions of the present day.

A.1. Appendix 1: Neolithic sites with existing botanical data

The following tables present collated existing data from Neolithic sites in and around the Alps, alongside contextual information regarding their geographical location and dates of occupation. To represent all data clearly, the complete datasheet has been split into numerous smaller tables comprising geographical data for each site, chronological data including radiocarbon dates and associated archaeological cultures, and crop macrofossil data. References for the data considered for each site is included in the final table.

Table 1. Geographical data for existing sites.

TABLE 1. THIS TABLE PRESENTS GEOGRAPHICAL INFORMATION REGARDING NEOLITHIC SITES WITH EXISTING ARCHAEOBOTANICAL DATA, IN AND AROUND THE ALPS.

Site Name	Country	Region	Altitude above sea level (m)	Latitude (Y)	Longitude (X)	Site type
Mariahilfberg I Brixlegg	Austria	Tyrol	534	47.427	11.882	Open air
Antonnaire Hearth 2	France	Drôme	1200	44.693333	5.361111	Cave
Aulp Du Seuil	France	Isere	1720	45.36737	5.902766	Rock shelter
Bessans Le Chateau	France	Savoie	1750	45.347222	7.026944	Open air
Chalain Station 19	France	Jura	489	46.669418	5.775339	Wet
Charavines Les Baigneurs	France	Isere	500	45.4361	5.5169	Wet
Clairvaux Station II	France	Jura	525	46.570893	5.751837	Wet
Clairvaux station III	France	Jura	525	46.570515	5.749138	Wet
Derriere Le Chateau	France	Ain	535	46.1871	5.5618	Open air
Fontbregoua	France	Var	400	43.55	6.2333	Cave
Gardon	France	Ain	360	45.956944	5.3875	Cave
Giribaldi Nice	France	Alpes Maritimes	70	43.710466	7.276067	Open air
Grande Rivoire	France	Isere	580	45.22165	5.644459	Rock shelter
La Motte Aux Magnins Level V	France	Jura	525	46.57086	5.749724	Wet
Le Chenet Des Pierres	France	Savoie	940	45.435	6.645556	Open air
Les Balmes	France	Savoie	1350	45.264722	6.815278	Cave
Pendimoun Castellar	France	Alpes Maritimes	690	43.813056	7.506111	Rock shelter
Saint Paul Trois Chateaux Le Valladas	France	Drôme	100	44.343773	4.760579	Rock shelter
Saint Paul Trois Chateaux Les Moulins	France	Drôme	100	44.342278	4.751668	Open air
Trou Arnaud	France	Drôme	720	44.5648	5.3223	Cave
Freiberg Geisingen	Germany	Necker Valley	220	48.9333	9.1833	Open air
Hornstaad Hornlel A	Germany	Lake Constance	400	47.69479	9.005774	Wet
Odenahlen	Germany	Federsee	580	48.119211	9.640983	Wet

Sipplingen Osthafen layers 11 to 15	Germany	Lake Constance	398	47.79472	9.10024	Wet
Strandbad Allensbach	Germany	Lake Constance	401	47.709758	9.079814	Wet
Wangen Hinterhorn	Germany	Lake Constance	402	47.66095	8.938894	Wet
Ziegelhutte Wallhausen	Germany	Lake Constance	415	47.747577	9.140295	Wet
Hauslab Pass Otzi Mummy	Italy	Trentino Alto Adige	3210	46.779389	10.840306	Glacier
Arene Candide	Italy	Liguria	90	44.1618	8.326389	Cave
Armadell Aquila	Italy	Liguria	230	44.2047156	8.3296647	Rock shelter
Balm Chanto	Italy	Piedmont	1390	45.025364	7.123807	Rock shelter
Casalnoceto	Italy	Lombardy	159	44.907618	8.9748001	Well
Casatico	Italy	Lombardy	30	45.116667	10.533333	Open air
Castello di Annone	Italy	Piedmont	650	44.87836	8.3154	Open air
Cecima	Italy	Lombardy	331	44.85	9.08333	Open air
Fagnigola	Italy	Friuli Venezia Giuli	9	45.85668	12.67518	Open air
Isolino Virginia	Italy	Lombardy	241	45.81185	8.71575	Wet
Isorella	Italy	Lombardy	50	45.3	10.3166	Open air
La Vela II	Italy	Trentino Alto Adige	190	46.081	11.0314	Open air
La Vela VIII	Italy	Trentino Alto Adige	275	46.081	11.0314	Open air
Monte Covolo	Italy	Lombardy	290	45.6002	10.4701	Open air
Mosio	Italy	Lombardy	30	45.1494	10.4721	Open air
Ostiano Dugali Alti	Italy	Lombardy	50	45.2166	10.25	Open air
Palu Di Livenza	Italy	Friuli Venezia Giuli	30	46.0151	12.4779	Wet
Pizzo di Bodio	Italy	Lombardy	240	45.8	8.7143	Wet
Rivarolo Mantovano	Italy	Lombardy	30	45.0727	10.4371	Open air
Rocca Di Manerba	Italy	Lombardy	200	45.5626	10.5529	Open air
Sammardenchia Cueis	Italy	Friuli Venezia Giuli	67	45.9824	13.203	Open air
Tolerait	Italy	Trentino Alto Adige	350	46.4892	11.3121	Open air
Valgrana Tetto Chiappello	Italy	Piedmont	960	44.2731	7.5153	Open air
Vho Campo Ceresole	Italy	Lombardy	30	45.1292	10.3675	Open air
Aabach Risch Oberrisch	Switzerland	Lake Zug	440	47.1239	8.4544	Wet
AKAD Presshaus JC2	Switzerland	Lake Zurick	405	47.3646	8.5545	Wet
Auvernier Brises Lames	Switzerland	Lake Neuchatel	430	46.9713	6.8757	Wet
Av Ritz Les Saturnales	Switzerland	Valais	530	46.2356	7.3586	Open air
Burgaschisee Sud	Switzerland	Seeberg	465	47.1671	7.6674	Wet
Cham Eslen	Switzerland	Lake Zug	410	47.1753	8.4533	Wet
Cham St Andreas	Switzerland	Lake Zug	410	47.1783	8.4664	Wet
Champs Devant Vaumarcus	Switzerland	Lake Neuchatel	435	46.8745	6.7572	Open air
Concise Sous Colachoz Ensemble 2	Switzerland	Lake Neuchatel	430	46.8472	6.7175	Wet
Derriere La Croix Saint Aubin	Switzerland	Lake Neuchatel	435	46.8794	6.7605	Open air
Egolzwil 3	Switzerland	Wauwilermoos	690	47.1823	8.0164	Wet
Horgen Scheller layers 3 and 4	Switzerland	Lake Zurick	409	47.2692	8.5868	Wet
Hanenberg Chamleten	Switzerland	Lake Zug	420	47.1691	8.4499	Wet
Kan San	Switzerland	Lake Zurick	405	47.3556	8.5486	Wet
Kempten Wetzikon	Switzerland	Lake Zurick	562	47.3318	8.8175	Open air
Kleiner Hafner	Switzerland	Lake Zurick	400	47.3661	8.544	Wet
La Baume Villeneuve Abri 1	Switzerland	Fribourg	600	46.7464	6.8639	Rock shelter
La Gilliere 1 and 2	Switzerland	Valais	510	46.2	7.3	Open air
Luscherz Kleine Station XV	Switzerland	Lake Bienne	434	47.047	7.1468	Wet
Mythenschloss	Switzerland	Lake Zurick	400	47.3594	8.5345	Wet
Niederwil Gachnang	Switzerland	Egelsee	402	47.5589	8.8601	Wet
Pfafersbuel Sevelen	Switzerland	Saint Gall	485	47.1255	9.4809	Open air
Pfaffikon Burg	Switzerland	Lake Zurick	540	47.363989	8.77817	Wet
Port Studeli USOS	Switzerland	Lake Bienne	448	47.1178	7.2576	Wet

Riet Oberrieden	Switzerland	Lake Zurick	405	47.2756	8.5819	Wet
Saint Blaise Bains Des Dames	Switzerland	Lake Neuchatel	427	47.009	6.9844	Wet
Saviese La Soie	Switzerland	Valais	850	46.2434	7.3264	Open air
Schlossmatte	Switzerland	Lake Bienne	430	47.1291	7.2385	Wet
Sion Petit Chasseur IV	Switzerland	Valais	490	46.2318	7.3514	Open air
Sion Tourbillon	Switzerland	Valais	650	46.2367	7.3689	Open air
Surles Rochettes Est Cortaillod	Switzerland	Lake Neuchatel	485	46.9469	6.8399	Open air
Sutz Lattrigen VI Riedstation	Switzerland	Lake Bienne	445	47.0994	7.208	Wet
Sutz Lattrigen VII Hauptstation	Switzerland	Lake Bienne	445	47.0985	7.2056	Wet
Thaygen Weier	Switzerland	Lake Constance	417	47.736	8.4329	Wet
Twann	Switzerland	Lake Bienne	426	47.0934	7.1567	Wet
Vorstadt 26	Switzerland	Lake Zug	416	47.1693	8.5143	Wet
Zizers Friedau	Switzerland	Grisons	540	46.9342	9.5627	Open air
Zurich Mozartstrasse	Switzerland	Lake Zurick	400	47.3639	8.5474	Wet

Table 2. Dating and chronological data from existing sites.

TABLE 2. DATA RELATING TO THE DATING AND CHRONOLOGY OF OCCUPATION AT THE SITES CONSIDERED DURING IN THIS ANALYSIS IS PRESENTED IN THE FOLLOWING TABLE.

Site Name	Period	Start	End	Archaeological culture
Mariahilfberg I Brixlegg	Middle Neolithic 2	3650	3534	Munchshofen
Antonnaire Hearth 2	Middle Neolithic 2	3910	3365	Chasséen
Aulp Du Seuil	Middle Neolithic 1	4450	4250	.
Bessans Le Chateau	Middle Neolithic	.	.	VBQ
Chalain Station 19	Late Neolithic	3060	2970	Clairvaux Ancien
Charavines Les Baigneurs	Late Neolithic	2400	2300	Luscherz
Clairvaux Station II	Late Neolithic	3550	3400	Late Cortaillod
Clairvaux station III	Late Neolithic	.	.	Cortaillod
Derriere Le Chateau	Late Neolithic	2500	2200	Campaniforme
Fontbregoua	Early Neolithic	.	.	Cardial/Prechasséen
Fontbregoua	Middle Neolithic 1	.	.	Chasséen Ancien
Fontbregoua	Middle Neolithic 2	.	.	Chasseen Recent
Gardon	Middle Neolithic 1	4700	4250	St Uze
Giribaldi Nice	Middle Neolithic 2	4321	3796	VBQ/Chasséen
Grande Rivoire	Middle Neolithic 1	4800	4000	Epicardial/Chasséen
Grande Rivoire	Middle Neolithic 2	4000	2600	Chasséen
La Motte Aux Magnins Level V	Middle Neolithic 2	3660	3525	Burgundian Middle Neolithic
Le Chenet Des Pierres	Middle Neolithic 1	4400	4200	VBQ/Chasséen
Le Chenet Des Pierres	Middle Neolithic 2	4000	3500	VBQ/Chasséen
Les Balmes	Middle Neolithic 2	3700	3100	Chasséen
Les Balmes	Late Neolithic	3100	2900	Cortaillod
Pendimoun Castellar	Late Neolithic	.	.	Campaniforme
Pendimoun Castellar	Middle Neolithic	.	.	.
Pendimoun Castellar	Early Neolithic	.	.	Cardial/Impressa
Saint Paul Trois Chateaux Le Valladas	Early Neolithic	5030	4800	Cardial
Saint Paul Trois Chateaux Les Moulins	Middle Neolithic	4500	3700	Chasséen
Trou Arnaud	Middle Neolithic 1	4400	4000	Chasséen
Freiberg Geisingen	Late Neolithic	.	.	Schussenrieder
Hornstaad Hornlel A	Middle Neolithic 2	3919	3905	Pfyn
Odenahlen	Late Neolithic	3700	3688	Pfyn/Altheim
Sipplingen Osthafen layers 11 to 15	Late Neolithic	3700	3500	Pfyn
Strandbad Allensbach	Late Neolithic	3147	2420	Horgen
Wangen Hinterhorn	Middle to Late Neolithic	4000	2500	Pfyn/Michelsberg/Horgen
Ziegelhutte Wallhausen	Middle to Late Neolithic	3700	2900	Pfyn
Hauslab Pass Otzi Mummy	Late Neolithic	3300	.	.
Arene Candide	Early Neolithic	.	.	Impressa
Arene Candide	Middle Neolithic	.	.	VBQ II
Armadell Aquila	Middle Neolithic	.	.	VBQ

Balm Chanto	Late Neolithic	2100	2000	.
Casalnoceto	Middle Neolithic	.	.	VBQ
Casatico	Middle Neolithic	.	.	VBQ
Castello di Annone	Middle Neolithic	.	.	.
Cecima	Early Neolithic	4990	4710	Vhó
Fagnigola	Middle Neolithic 2	4000	3700	Fiorano
Isolino Virginia	Early to Middle Neolithic	.	.	Chassey type Lagozza/Cortaillod
Isorella	Early Neolithic	.	.	Vhó/Fiorano
La Vela II	Early Neolithic	.	.	.
La Vela II	Middle Neolithic 1	.	.	VBQ
La Vela VIII	Middle Neolithic 2	.	.	VBQ
Monte Covolo	Middle Neolithic 2	3760	3300	Chassey type Lagozza
Monte Covolo	Late Neolithic	.	.	Whiteware/Horgen
Monte Covolo	Late Neolithic	.	.	Campaniforme
Mosio	Middle Neolithic 2	3986	3820	VBQ
Ostiano Dugali Alti	Early Neolithic	.	.	Vhó
Palu Di Livenza	Middle Neolithic 2	3960	3260	VBQ/Chassey type Lagozza
Pizzo di Bodio	Early Neolithic	5200	4800	Impressa
Rivarolo Mantovano	Middle Neolithic	.	.	VBQ
Rocca Di Manerba	Middle Neolithic	.	.	Chassey type Lagozza
Rocca Di Manerba	Late Neolithic	.	.	Remadello
Sammardenchia Cueis	Early Neolithic	5549	4461	Fiorano
Tolerait	Late Neolithic	2180	2180	.
Valgrana Tetto Chiappello	Middle Neolithic 1	4500	4200	VBQ
Vho Campo Ceresole	Early Neolithic	5260	4780	Vhó
Aabach Risch Oberrisch	Middle Neolithic 2	4000	4000	Pfyn
AKAD Presshaus JC2	Middle Neolithic 2	3735	3667	Pfyn
Auvernier Brises Lames	Late Neolithic	2300	2000	Lucherz
Av Ritz Les Saturnales	Middle Neolithic	4250	3750	.
Burgaschisee Sud	Late Neolithic	2800	2600	Cortaillod
Cham Eslen	Middle Neolithic 1	4350	4000	Egolzwil
Cham St Andreas	Middle Neolithic 2	3943	3632	Cortaillod/Pfyn
Champs Devant Vaumarcus	Middle Neolithic 1	4500	4250	Early Cortaillod
Champs Devant Vaumarcus	Middle Neolithic 2	4000	3700	Classic Cortaillod
Concise Sous Colachoz Ensemble 2	Middle Neolithic 2	3710	3677	Cortaillod
Derriere La Croix Saint Aubin	Middle Neolithic	4800	3800	St Uze
Derriere La Croix Saint Aubin	Late Neolithic	.	.	.
Egolzwil 3	Middle Neolithic 1	4300	4300	Egolzwil
Horgen Scheller layers 3 and 4	Late Neolithic	3050	3035	Horgen
Hanenberg Chamleten	Middle to Late Neolithic	.	.	Horgen
Kan San	Late Neolithic	.	.	Cortaillod/Pfyn
Kempten Wetzikon	Late Neolithic	2400	2200	Campaniforme
Kleiner Hafner 4AB	Middle Neolithic 1	4250	4050	Early Cortaillod
Kleiner Hafner 4EF	Middle Neolithic 2	4000	3800	Cortaillod/Pfyn
Kleiner Hafner 5AB	Middle Neolithic 1	4450	4250	Egolzwil
La Baume Villeneuve Abri 1	Late Neolithic	3020	2900	Luscherz
La Gilliere 1 and 2	Early Neolithic	4900	.	Early Cortaillod
La Gilliere 1 and 2	Middle Neolithic 1	.	4450	Cortaillod
Luscherz Kleine Station XV	Late Neolithic	3403	3386	Horgen
Mythenschloss Layer 2	Late Neolithic	2680	2548	Corded ware
Mythenschloss Layer 3	Late Neolithic	3200	3200	Horgen
Niederwil Gachnang	Middle Neolithic 2	3660	3595	Pfyn

Pfafersbuel Sevelen	Middle Neolithic 1	4300	4000	Epi Rossen
Pfaffikon Burg	Late Neolithic	3400	2800	Horgen
Port Studeli USOS	Middle Neolithic 2	3700	3500	Early Cortaillod
Riet Oberrieden	Late Neolithic	3000	.	Horgen
Saint Blaise Bains Des Dames	Late Neolithic	2640	2450	Corded ware
Saviese La Soie	Middle Neolithic 1	4680	4250	.
Saviese La Soie	Late Neolithic	3500	3100	Luscherz
Schlossmatte	MiddleLateNeo	3410	3380	Horgen
Sion Petit Chasseur IV	Middle Neolithic 2	4000	3800	Cortaillod
Sion Tourbillon	Early Neolithic	4930	4767	.
Surles Rochettes Est Cortaillod	Late Neolithic	2450	2100	Lucherz-Auvernier
Sutz Lattrigen VI Riedstation	Late Neolithic	3393	3388	Horgen
Sutz Lattrigen VII Hauptstation	Late Neolithic	3202	3013	Horgen
Thaygen Weier	Middle Neolithic 2	3822	3584	Pfyn
Twann	Middle Neolithic 2	3593	3573	Cortaillod
Twann	Late Neolithic	3176	3072	Horgen
Vorstadt 26	Late Neolithic	3400	2800	Horgen
Zizers Friedau	Early Neolithic	4800	4800	LBK type Hinkelstein
Zurich Mozartstrasse Layer 6	Middle Neolithic 1	.	.	Early Cortaillod
Zurich Mozartstrasse Layer 5	Middle Neolithic 1	.	.	Classic Cortaillod
Zurich Mozartstrasse Layer 3	Late Neolithic	3124	2883	Horgen
Zurich Mozartstrasse Layer 2	Late Neolithic	2700	2499	Corded ware

Table 3. Collated Alpine macrofossil data.

TABLE 3. CROP MACROFOSSIL DATA IS COLLATED IN THE FOLLOWING TABLE FROM PREVIOUS STUDIES OF KNOWN NEOLITHIC SITES IN AND AROUND THE ALPS.

In the case of semi-quantitative data, frequencies are symbolised as follows:
x = present. xx = common. xxx = abundant.

Site Name	*Triticum monococcum*	*Triticum dicoccum*	*Triticum nudum*	*Triticum spelta*	*Triticum* sp.	*Hordeum* sp.	*Cerealia* type	New glume wheat'	Total cereals	Dominant cereal type	*Pisum sativum*	*Lens culinaris*	*Papaver somniferum*	*Linum usitatissimum*
Mariahilfberg I Brixlegg	.	x	x	.	.	x	.	.	.	.	x	.	.	.
Antonnaire Hearth 2	.	14%	52%	.	.	34%	xxx	.	3181	*T. nudum*	.	.	.	.
Aulp Du Seuil	3	.	4	.	.	1	29	.	37	.	.	.	.	.
Bessans Le Chateau	.	.	.	.	.	xxx	.	.	.	*Hordeum* sp.	.	.	.	.
Chalain Station 19	x	x	.	.	xxx	x	xxx	.	.	*Triticum* sp.	.	.	xxx	xx
Charavines Les Baigneurs	.	5822	390	.	.	57	.	.	.	*T. dicoccum*	.	.	xxx	xx
Clairvaux Station II	.	x	x	.	.	x	.	.	26	.	x	.	xx	xx
Clairvaux station III	.	x	x	.	.	xxx	x	.	.	*Hordeum* sp.	x	.	xxx	xx
Derriere Le Chateau	x	xx	x	.	.	xxx	.	.	.	*Hordeum* sp.	.	x	.	x
Fontbregoua (Early)	1	9	89	.	42	16	.	.	157	*T. nudum*	.	.	.	.
Fontbregoua (Mid Neo 1)	411	177	306	.	212	7	.	.	1064	*T. monococcum*	.	.	.	.
Fontbregoua (Mid Neo 2)	9	7	19	.	13	1	.	.	49	*T. nudum*	.	.	.	.
Gardon	.	.	2	.	1	1	2	.	6	.	.	.	.	.
Giribaldi Nice	9	56	307	.	22	135	96	.	625	*T. nudum*	1	1	.	.
Grande Rivoire (Mid Neo 1)	3	.	4	.	.	4	.	.	11	.	.	.	.	.
Grande Rivoire (Mid Neo 2)	5	5	6	.	.	6	.	.	22	.	.	.	.	.
La Motte Aux Magnins Level V	.	665	22	.	.	5	.	.	932	*T. dicoccum*	10	.	7203	225
Le Chenet Des Pierres (Mid Neo 1)	20	.	3	.	.	284	.	.	.	*Hordeum* sp.	1	.	421	.
Le Chenet Des Pierres (Mid Neo 2)	106	22	571	.	.	422	.	.	.	*T. nudum*	140	.	.	.
Les Balmes (Mid Neo 2)	22147	143	598	.	.	303	.	.	23191	*T. monococcum*	1	.	.	.
Les Balmes (Late Neo)	5685	327	676	.	.	11864	.	.	18552	*Hordeum* sp.	.	.	.	.
Pendimoun Castellar (Late Neo)	.	.	x	.	.	xx	x	.	26	*Hordeum* sp.	.	.	.	.
Pendimoun Castellar (Mid Neo)	.	x	x	.	.	x	.	.	8	*Hordeum* sp.	.	.	.	.
Pendimoun Castellar (Early Neo)	7	.	2	.	4	6	6	.	25	*Hordeum* sp.	.	.	.	.
Saint Paul Trois Chateaux Le Valladas	1	1	2	.	.	3	.	.	18950	*Hordeum* sp.	2	.	.	.
Saint Paul Trois Chateaux Les Moulins	138	29	36	.	6	1712	26	.	1931	*Hordeum* sp.	1	.	.	.
Trou Arnaud	2163	1086	39	.	590	587	237	.	.	*T. monococcum*	349	76	.	.
Freiberg Geisingen	1379	21	1	.	2	611	.	.	.	*T. monococcum*	1	.	.	.
Hornstaad Hornlel A	.	9	41	.	.	65	.	.	.	*Hordeum* sp.	.	.	1219	4845
Odenahlen	356	1482	3727	.	2098	863	.	.	.	*T. nudum*	.	.	202	2846
Sipplingen Osthafen layers 11 to 15	1389	353	35815	.	1461	1937	1	.	23281	*T. dicoccum*	.	.	201	4753
Strandbad Allensbach	x	xxx	xx	.	x	xx	.	.	.	*T. dicoccum*	.	.	.	.
Wangen Hinterhorn	xx	xx	xx	.	.	xxx	.	.	.	*Hordeum* sp.	x	.	xxx	xxx

Ziegelhutte Wallhausen	8	24	1304	.	.	211	.	.	.	*T. nudum*	.	.	699	1096
Hauslab Pass Otzi Mummy	x	.	.	.	x	x	x	.	.	.	.	.	.	.
Arene Candide (Early Neo)	9.3%	16.9%	9.2%	.	9.2%	16.9%	38.5%	.	65	*Hordeum* sp./*T. dicoccum*	.	x	.	.
Arene Candide (Mid Neo)	.	10	1	.	.	6	.	.	.	*T. dicoccum*	.	.	.	.
Armadell Aquila	.	.	.	.	.	x	.	.	.	*Hordeum* sp.	.	.	.	.
Balm Chanto	.	x	x	.	.	xxx	.	.	102	*Hordeum* sp.	.	.	.	.
Casalnoceto	.	.	.	.	x	.	.	.	.	*Triticum* sp.	.	.	.	.
Casatico	x	x	.	.	.	x	.	.	.	.	.	.	.	.
Castello di Annone	x	x	x	.	.	x	.	.	.	.	.	.	.	.
Cecima	.	.	.	.	.	x	.	.	12	*Hordeum* sp.	.	.	.	.
Fagnigola	.	x	x	.	.	x	xx	.	32	.	.	.	.	.
Isolino Virginia	.	x	.	.	x	xx	.	.	46	*Hordeum* sp.	.	.	.	.
Isorella	x	x	x	.	.	.	.	.	7	*Triticum* sp.	.	.	.	.
La Vela II (Early Neo)	x	x	.	.	x	x	xx	.	39	.	.	.	.	.
La Vela II (Mid 1)	10	6	.	.	13	7	79	.	89	.	1	.	.	.
La Vela VIII	75	151	90	.	13	4	158	55	506	*T. dicoccum*	3	.	.	.
Monte Covolo (Mid Neo)	3	39	.	.	.	13	36	.	91	*T. dicoccum*	.	.	.	.
Monte Covolo (Horgen layers)	x	xxx	.	.	.	xx	xx	.	138	*T. dicoccum*	.	.	.	.
Monte Covolo (Campaniforme layers)	x	xxx	.	.	.	xx	xx	.	222	*T. dicoccum*	.	.	.	.
Mosio	x	x	.	.	.	x	.	.	.	.	.	.	.	.
Ostiano Dugali Alti	x		.	.	.	x	.	.	.	.	.	.	.	.
Palu Di Livenza	x	x	x	.	x	x	.	.	.	.	.	.	x	x
Pizzo di Bodio	.	x	.	.	x	x	.	.	.	.	.	.	.	.
Rivarolo Mantovano	.	x	.	.	.	x	.	.	.	.	x	.	.	.
Rocca Di Manerba (Mid Neo)	x	x	x	.	.	x	.	.	.	.	.	x	.	.
Rocca Di Manerba (Late Neo)	x	.	.	.	.	.	.	.	.	*T. monococcum*	.	x	.	.
Sammardenchia Cueis	xx	xx	xx	x	xx	xxx	xxx	.	4200	*Hordeum* sp.	x	x	.	.
Tolerait	x	x	.	.	.	x	.	.	.	.	.	.	.	.
Valgrana Tetto Chiappello	78	32	73	138	96	850	3074	.	4341	*Hordeum* sp.	50	.	.	.
Vho Campo Ceresole	x	.	x	.	.	x	.	.	5	.	.	.	.	.
Aabach Risch Oberrisch	.	14	6682	.	.	5512	.	.	.	*T. nudum*	.	.	60010	6044
AKAD Presshaus JC2	89	448	9565	54	.	1411	.	.	11509	*T. nudum*	4	.	130752	30822
Auvernier Brises Lames	.	x	x	.	x	x	.	.	.	.	.	.	x	x
Av Ritz Les Saturnales	.	.	3	.	.	.	.	.	.	*T. nudum*	.	.	.	.
Burgaschisee Sud	7	9	193	.	.	183	.	.	.	*Hordeum* sp./*T. nudum*	10	.	3000	21
Cham Eslen	5	3	5	.	3	17	.	.	.	*Hordeum* sp.	6	.	3	3938
Cham St Andreas	.	14	710	.	.	212	.	.	.	*T. nudum*	3	.	.	.
Champs Devant Vaumarcus (Mid Neo 1)	x	x	x	.	.	.	x	.	28	.	.	.	.	.
Champs Devant Vaumarcus (Mid Neo 2)	x	x	xx	.	.	x	x	.	576	*T. nudum*	.	.	.	.
Concise Sous Colachoz Ensemble 2	8	1	6	.	.	4	.	.	.	.	1	.	2107	469
Derriere La Croix Saint Aubin (Mid Neo)	x	x	xxx	.	x	x	xxx	.	3746	*T. nudum*	.	.	.	x
Derriere La Croix Saint Aubin (Late Neo)	x	x	x	.	x	x	x	.	55	.	.	.	.	.
Egolzwil 3	3	1	89	.	1	76	.	.	189	*Hordeum* sp./*T. nudum*	29	1	4663	338
Horgen Scheller layers 3 and 4	x	xxx	xx	.	xx	x	xx	.	.	*T. dicoccum*	x	.	xxx	xxx
Hanenberg Chamleten	x	x	x	.	.	x	.	.	.	.	.	.	x	.
Kan San	134	333	22291	.	.	858	.	.	.	*T. dicoccum*/*T. nudum*	1	.	40097	6380
Kempten Wetzikon	x	xx	x	x	x	xx	xxx	.	867	*Hordeum* sp./*T. dicoccum*	x	.	.	.
Kleiner Hafner 4AB	x	x	xx	.	.	xxx	.	.	14061	*Hordeum* sp.	x	.	xx	x
Kleiner Hafner 4EF	x	x	xxx	.	.	x	.	.	29878	*T. nudum*	x	.	xxx	xx
Kleiner Hafner 5AB	174	67	205	.	.	90	.	.	488	*T. nudum*	89	.	9182	27
La Baume Villeneuve Abri 1	.	xxx	x	.	x	xx	xxx	.	180000	*T. dicoccum*	.	.	.	.
La Gilliere 1 and 2 (Early Neo)	.	224	4248	.	2689	956	7358	.	15475	*T. nudum*	.	.	7027	.

La Gilliere 1 and 2 (Mid Neo 1)	.	2	21	.	15	73	107	.	218	*Hordeum* sp.	1	.	.	.
Luscherz Kleine Station XV	.	.	xxx	.	x	xx	.	.	4825	*T. nudum*	x	.	.	.
Mythenschloss Layer 2	x	xxx	x	.	.	x	.	.	11260	*T. dicoccum*	x	.	xx	xxx
Mythenschloss Layer 3	x	xxx	xx	.	.	x	.	.	135	*T. dicoccum*	x	.	xxx	xx
Niederwil Gachnang	.	54	61578	.	.	15786	.	.	74249	*T. nudum*	2	.	29818	41456
Pfafersbuel Sevelen	11	6	22	.	37	21	242	.	339	.	.	.	2	1
Pfaffikon Burg	x	xxx	xxx	.	xx	xx	xx	.	3735	*T. dicoccum*/*T. nudum*	x	.	xxx	xxx
Port Studeli USOS	3241	13683	4679	.	274	18391	.	.	39982	*Hordeum* sp.	72	.	1013	1423
Riet Oberrieden	.	x	xxx	.	.	.	.	.	.	*T. nudum*	.	.	.	.
Saint Blaise Bains Des Dames	xx	xx	xx	.	.	xxx	xxx	.	4707	*Hordeum* sp.	x	.	xxx	xxx
Saviese La Soie (Mid Neo 1)	1	8	52	.	42	1155	1700	.	2940	*Hordeum* sp.	69	.	.	.
Saviese La Soie (Late Neo)	xx	.	x	.	x	xx	xxx	.	4146	*Hordeum* sp./*T. monococcum*	xxx	x	.	.
Schlossmatte	.	x	xx	.	x	xxx	.	.	5435	*Hordeum* sp.	x	.	xxx	xxx
Sion Petit Chasseur IV	xxx	xx	x	.	.	x	.	.	6174	*T. monococcum*	x	.	.	.
Sion Tourbillon	.	1	224	.	34	36	292	.	587	*T. nudum*	.	.	6	.
Surles Rochettes Est Cortaillod	xx	xx	.	xx	xx	x	xxx	.	2649	*Triticum* sp.	.	x	.	x
Sutz Lattrigen VI Riedstation	.	.	xxx	.	x	xx	.	.	4788	*T. nudum*	.	.	.	.
Sutz Lattrigen VII Hauptstation	.	xx	x	.	x	xxx	.	.	3657	*Hordeum* sp.	.	.	xxx	xxx
Thaygen Weier	.	18	2571	.	11	106	.	.	.	*T. dicoccum*	.	.	904	181
Twann (Mid Neo 2)	x	x	xxx	x	x	xx	x	.	5306	*T. nudum*	xx	.	.	x
Twann (Late Neo)	x	x	xx	.	x	xxx	.	.	2356	*Hordeum* sp.	.	.	.	.
Vorstadt 26	x	xxx	xx	.	x	xx	xx	.	1758	*T. dicoccum*	x	.	.	.
Zizers Friedau	x	xx	x	.	xx	xxx	xxx	.	1518	*Hordeum* sp.	xx	.	x	.
Zurich Mozartstrasse Layer 6	x	x	xxx	.	.	x	.	.	6541	*T. nudum*	x	.	xx	x
Zurich Mozartstrasse Layer 5	x	xx	xxx	.	.	xx	.	.	315	*T. nudum*	x	.	xx	x
Zurich Mozartstrasse Layer 3	x	xx	xx	.	.	xx	.	.	27689	.	xx	.	xxx	xxx
Zurich Mozartstrasse Layer 2	x	xxx	x	.	.	x	.	.	1436	*T. dicoccum*	x	.	xx	xxx

Table 4. References for collated dataset.

TABLE 4. CITATIONS FOR THE PUBLICATIONS FROM WHICH EXISTING ARCHAEOBOTANICAL WAS COLLECTED FROM ARE PRESENTED IN THE FOLLOWING TABLE.

Site Name	References
Mariahilfberg l Brixlegg	Oeggl, 2000
Antonnaire Hearth 2	Beeching et al., 2000; Martin, unpublished
Aulp Du Seuil	Martin et al., 2012
Bessans Le Chateau	Martin, unpublished
Chalain Station 19	Schaal, 2002
Charavines Les Baigneurs	Lundstrom Baudais, 2005
Clairvaux Station II	Lundstrom Baudais, 1989a
Clairvaux station III	Lundstrom Baudais, 1986
Derriere Le Chateau	Vérot-Bourrely et al., 1997
Fontbregoua	Courtin and Erroux, 1974; Savard, 2000
Gardon	Voruz et al., 2004
Giribaldi Nice	Thiebault et al., 2004
Grande Rivoire	Delhon et al., 2008; Martin et al., 2011; Martin, 2014
La Motte Aux Magnins Level V	Lundstrom Baudais, 1989b
Le Chenet Des Pierres	Martin et al., 2008
Les Balmes	Martin, 2010; Martin, 2014
Pendimoun Castellar	Binder et al., 1993, (new analyses forthcoming)
Saint Paul Trois Chateaux Le Valladas	Martin, unpublished
Saint Paul Trois Chateaux Les Moulins	Martin, forthcoming
Trou Arnaud	See Appendix 5 of this volume
Freiberg Geisingen	Piening, 1988
Hornstaad Hornlel A	Billamboz et al., 1992; Maier, 1996; 1999; 2001
Odenahlen	Maier, 1988; 1995
Sipplingen Osthafen layers 11 to 15	Jacomet, 1990
Strandbad Allensbach	Karg, 1990
Wangen Hinterhorn	Riehl, 1993
Ziegelhutte Wallhausen	Rosch, 1990
Hauslab Pass Otzi Mummy	Oeggl 1995; Oeggl & Schoch, 2000
Arene Candide	Nisbet, 2006; 2008; Rottoli et Castiglioni, 2009
Armadell Aquila	Arobba, et al., 1987; Biagi & Nisbet, 1986
Balm Chanto	Castelletti & Motella de Carlo, 1998; Nisbet, 1987
Casalnoceto	Castelletti & Motella de Carlo, 1998; Nisbet, 1999
Casatico	Biagi et al., 1993
Castello di Annone	Castelletti & Motella de Carlo, 1998
Cecima	Biagi et al., 1993; Pessina & Rottoli, 1996; Rottoli, 1999
Fagnigola	Pessina & Rottoli, 1996; Pessina, 2001; Rottoli; 1999
Isolino Virginia	Evett & Renfrew, 1971; Rottoli,1999, (new analyses forthcoming)
Isorella	Starnini et al., 2000; Rottoli & Castiglioni, 2009
La Vela II	Mottes & Rottoli, 2006
La Vela VIII	Degasperi et al., 2006
Monte Covolo	Biagi et al., 1993; Pals & Voorips, 1979
Mosio	Biagi et al., 1993
Ostiano Dugali Alti	Pessina & Rottoli, 1996; Rottoli, 1999

Palu Di Livenza	Corti et al., 1998; Pini, 2004
Pizzo di Bodio	Pessina & Rottoli, 1996
Rivarolo Mantovano	Follieri, 1987; Biagi et al., 1993
Rocca Di Manerba	Barfield et al., 2002
Sammardenchia Cueis	Rottoli, 1999
Tolerait	Biagi & Nisbet, 1987; Oeggl, 2000
Valgrana Tetto Chiappello	Motella De Carlo & Venturino Gambari, 2004
Vho Campo Ceresole	Biagi et al., 1993; Castelletti, 1975; Pessina & Rottoli, 1996
Aabach Risch Oberrisch	Jacomet, 2007
AKAD Presshaus JC2	Jacomet, 2007
Auvernier Brises Lames	Lundstrom Baudais, 1978
Av Ritz Les Saturnales	Martin, unpublished
Burgaschisee Sud	Villaret von Rochow, 1967; Jacomet, 2007
Cham Eslen	Martinoli & Jacomet, 2002
Cham St Andreas	Jacomet, 1986
Champs Devant Vaumarcus	Akeret & Geith Chauviere, 2003
Champs Devant Vaumarcus	Akeret & Geith Chauviere, 2003
Concise Sous Colachoz Ensemble 2	Karg & Markle, 2002
Derriere La Croix Saint Aubin	Akeret & Geith Chauviere, 2003
Egolzwil 3	Bollinger, 1994a; 1994b; Rasmussen, 1993
Horgen Scheller layers 3 and 4	Favre, 2002
Hanenberg Chamleten	Jacquat & Hafner, 1996
Kan San	Brombracher & Jacomet, 1997
Kempten Wetzikon	Hosch & Jacomet in Rigert et al., 2005b
Kleiner Hafner	Jacomet; 1987, Jacomet et al., 1989; Brombacher & Dick, 1987
La Baume Villeneuve Abri 1	Vandorpe in Mauvilly et al., 2010
La Gilliere 1 and 2	Martin, 2015
Luscherz Kleine Station XV	Brombacher, 1997
Mythenschloss	Jacomet et al., 1989
Niederwil Gachnang	Van Zeit & Boekschoten Van Helsdingen, 1991
Pfafersbuel Sevelen	Rigert et al., 2005a
Pfaffikon Burg	Zibulski, 2017
Port Studeli USOS	Brombacher & Jacomet, 2003
Riet Oberrieden	Jacomet, 2004
Saint Blaise Bains Des Dames	Mermod, 2000
Saviese La Soie	Baudais, 1995; Martin, unpublished; Martin, 2015
Schlossmatte	Brombacher, 2000
Sion Petit Chasseur IV	Lundstrom Baudais & Martin, 2011
Sion Tourbillon	Martin, 2015
Surles Rochettes Est Cortaillod	Akeret, 2005; von Burg, 2002
Sutz Lattrigen VI Riedstation	Brombacher, 1997
Sutz Lattrigen VII Hauptstation	Brombacher, 1997
Thaygen Weier	Robinson & Rasmussen, 1989
Twann	Piening, 1981
Vorstadt 26	Jacomet & Wagner, 1987
Zizers Friedau	Brombacher & Vandorpe, 2012
Zurich Mozartstrasse	Brombacher & Dick, 1987; Jacomet et al., 1989

A.2. Appendix 2: Altitudinal distribution of cereal crops.

Graphs are presented in this appendix in which the core cereal crops from each site are plotted against their altitude above sea level (m), and their longitudinal position. This is overlain in relation to the altitudinal zones present in each region, divided by the northern Prealps, the western Alps and Rhône Valley, and the Central Alps and northern Italy. The altitudinal and regional boundaries of the altitudinal zones follow the descriptions presented in (Walsh & Giguet-Covex, 2019). These figures are referred to in Chapter 4.

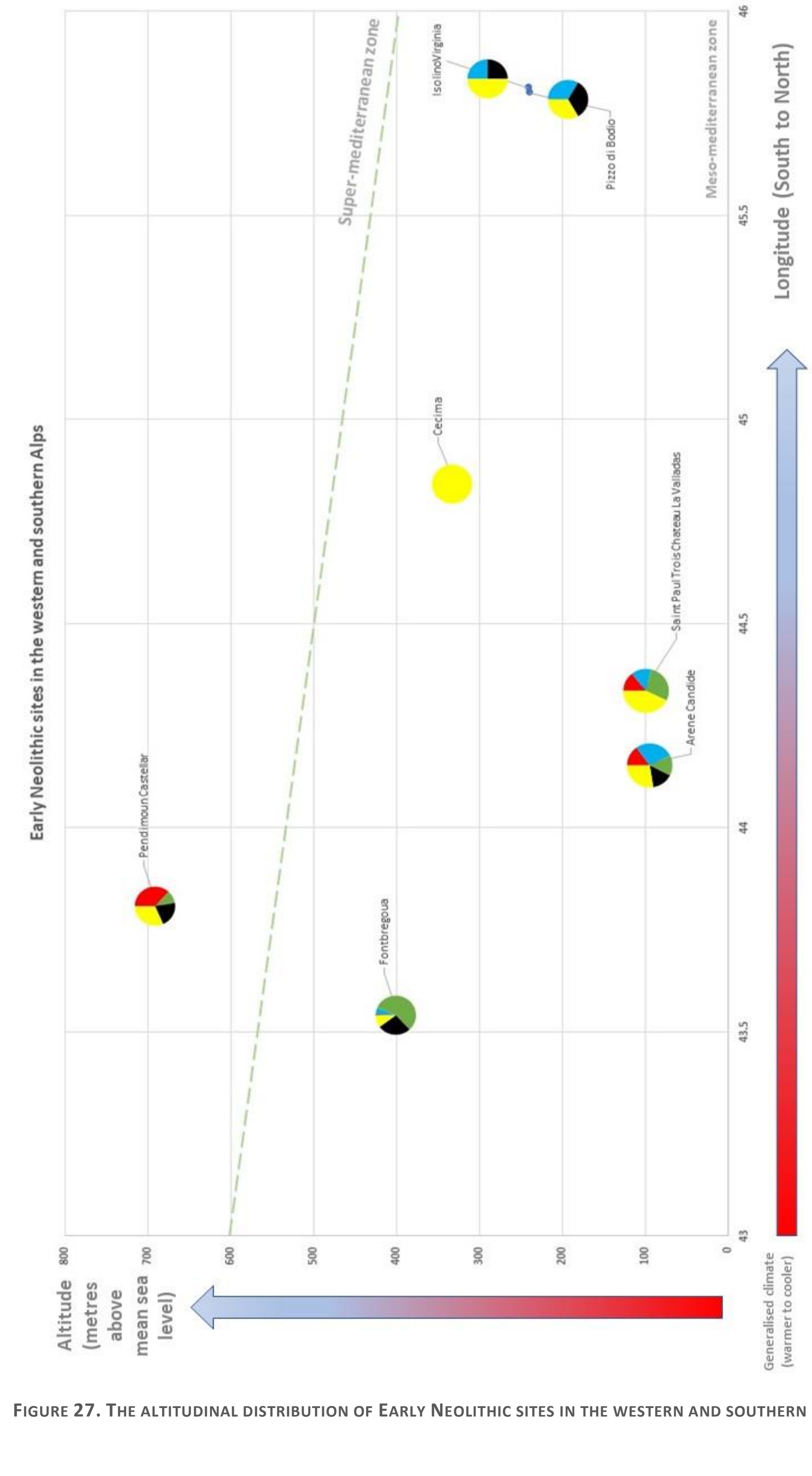


FIGURE 27. THE ALTITUDINAL DISTRIBUTION OF EARLY NEOLITHIC SITES IN THE WESTERN AND SOUTHERN ALPS.

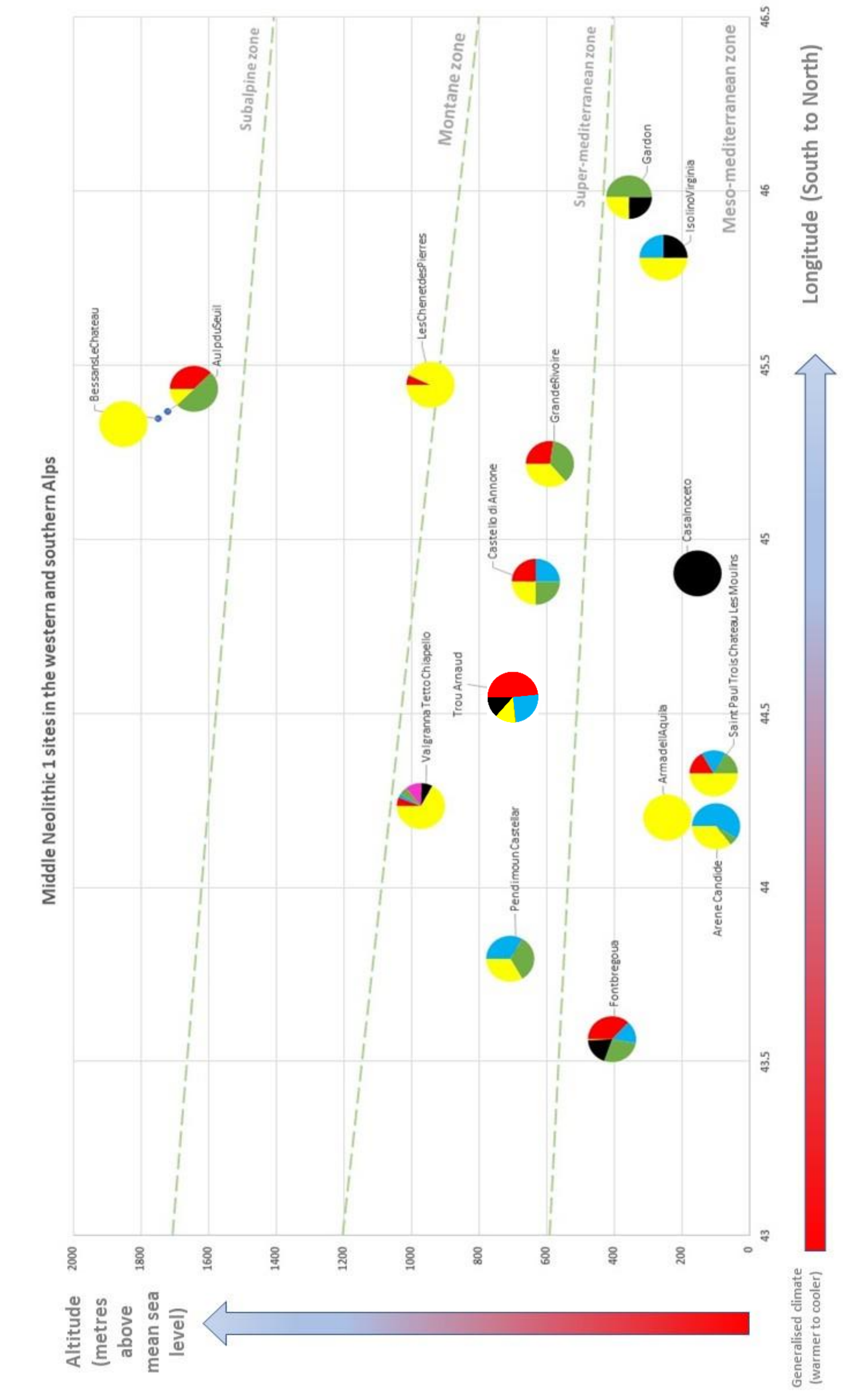


FIGURE 28. THE ALTITUDINAL DISTRIBUTION OF MIDDLE NEOLITHIC 1 SITES IN THE WESTERN AND SOUTHERN ALPS.

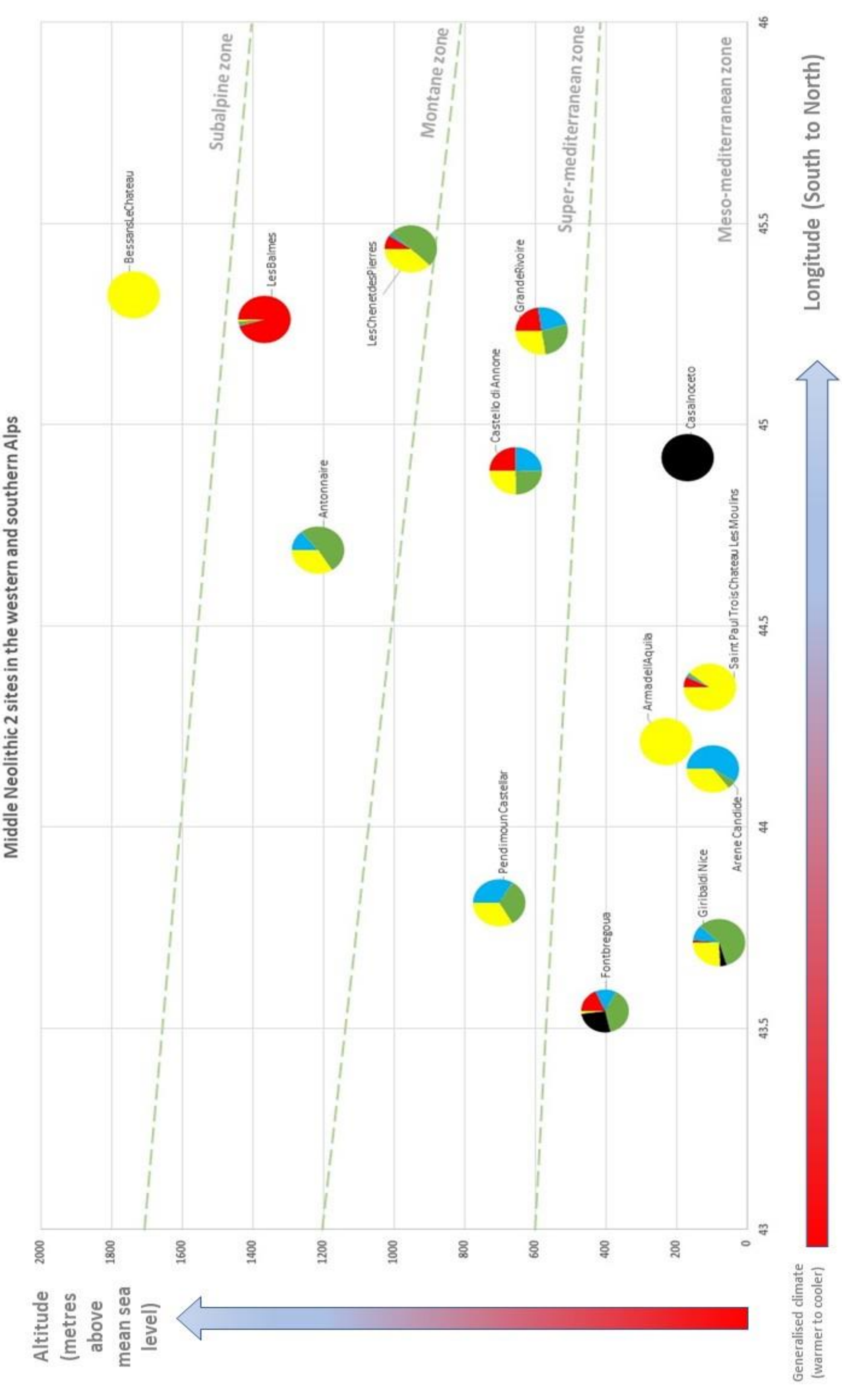


FIGURE 29. THE ALTITUDINAL DISTRIBUTION OF MIDDLE NEOLITHIC 2 SITES IN THE WESTERN AND SOUTHERN ALPS.

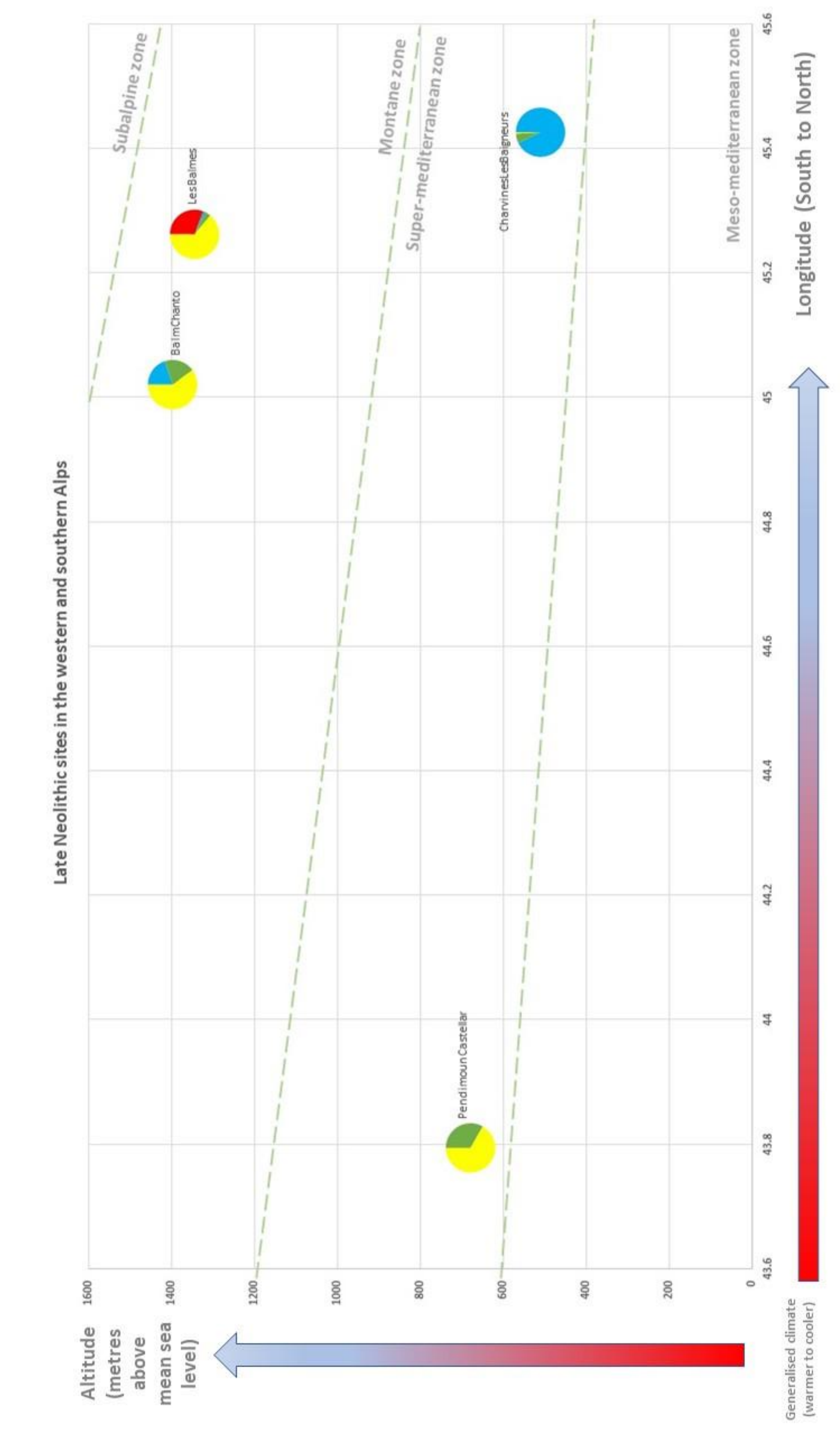


FIGURE 30. THE ALTITUDINAL DISTRIBUTION OF LATE NEOLITHIC SITES IN THE WESTERN AND SOUTHERN ALPS.

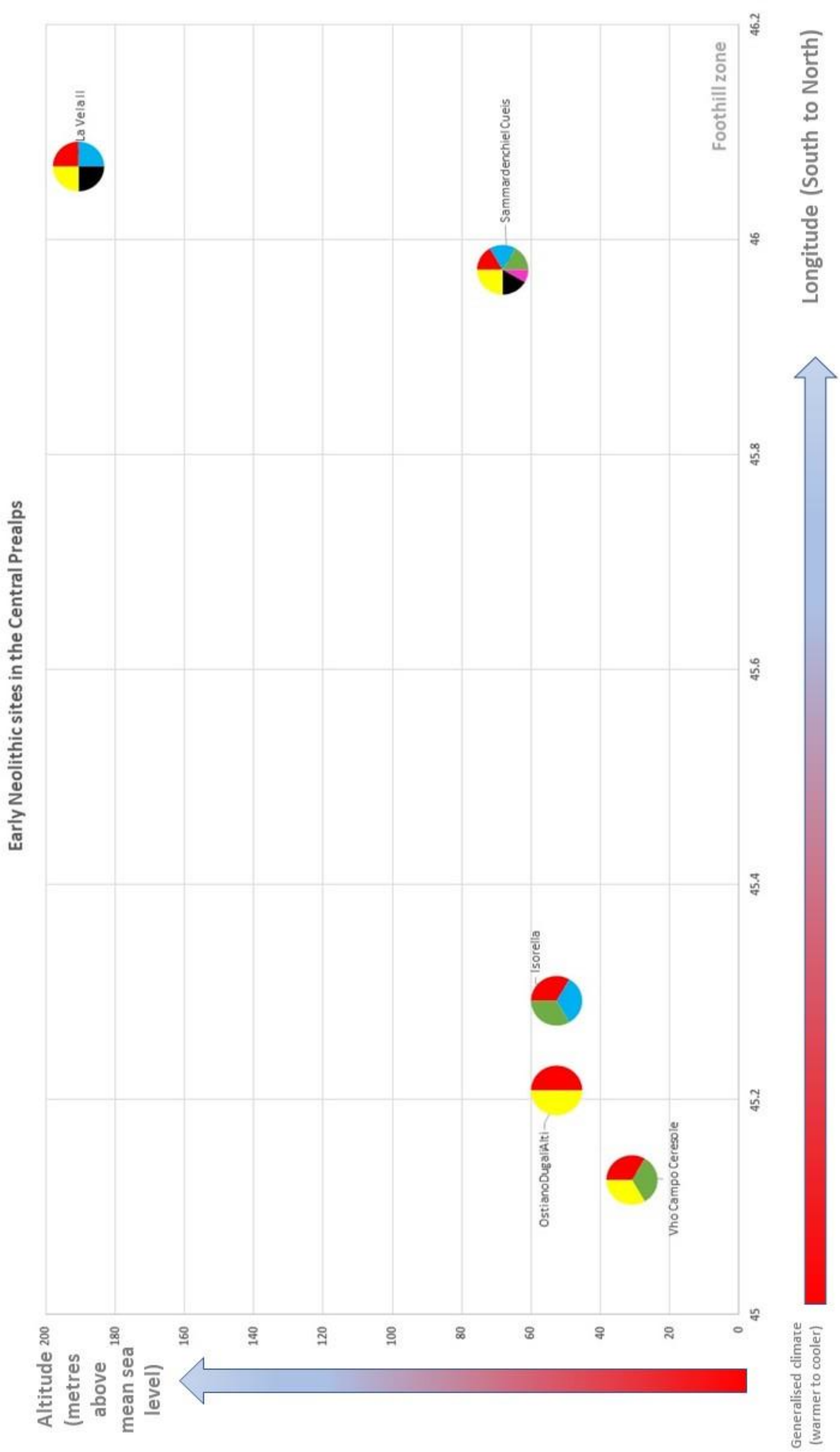


FIGURE 31. THE ALTITUDINAL DISTRIBUTION OF EARLY NEOLITHIC SITES IN THE CENTRAL ALPS AND NORTHERN ITALY.

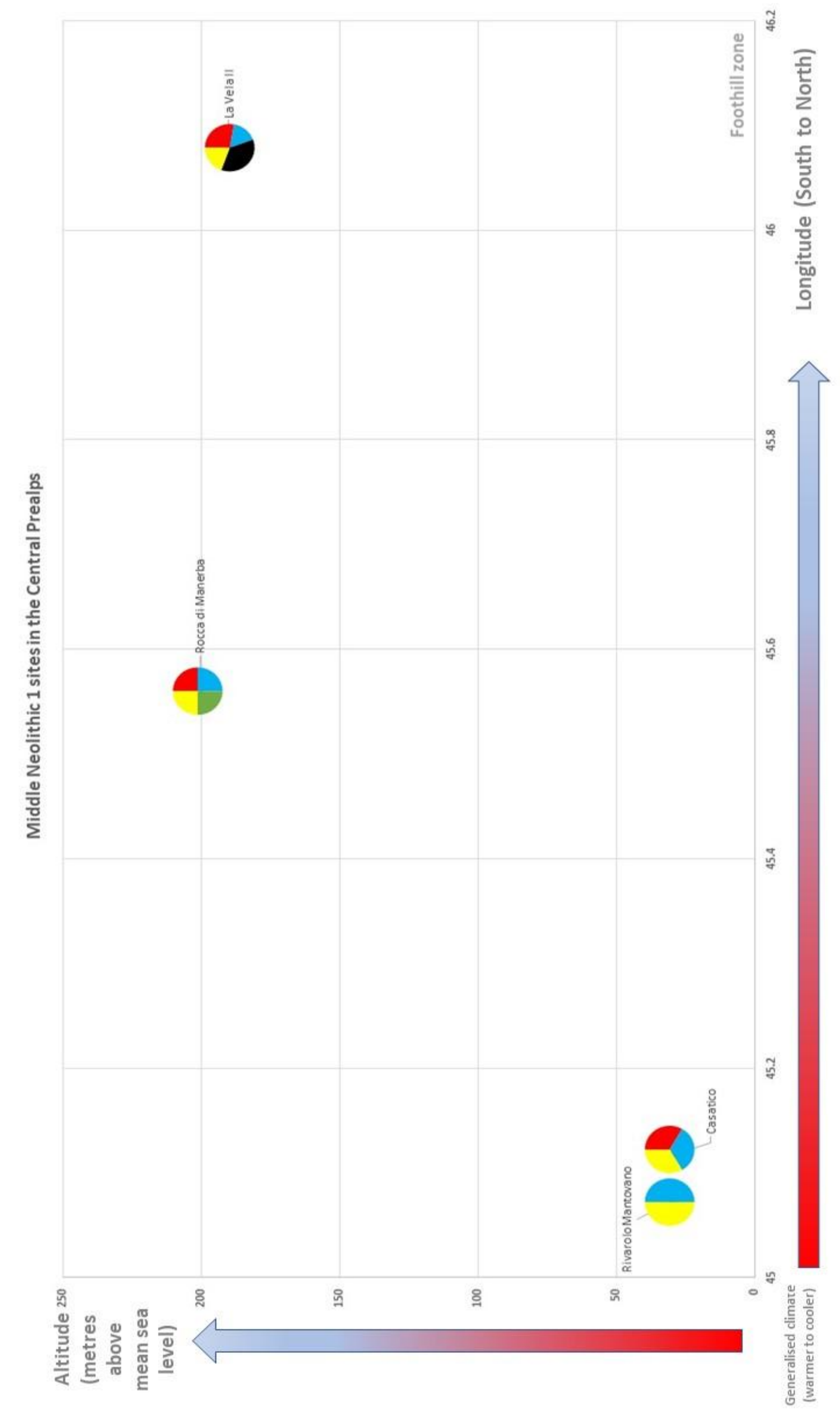


FIGURE 32. THE ALTITUDINAL DISTRIBUTION OF MIDDLE NEOLITHIC 1 SITES IN THE CENTRAL ALPS AND NORTHERN ITALY.

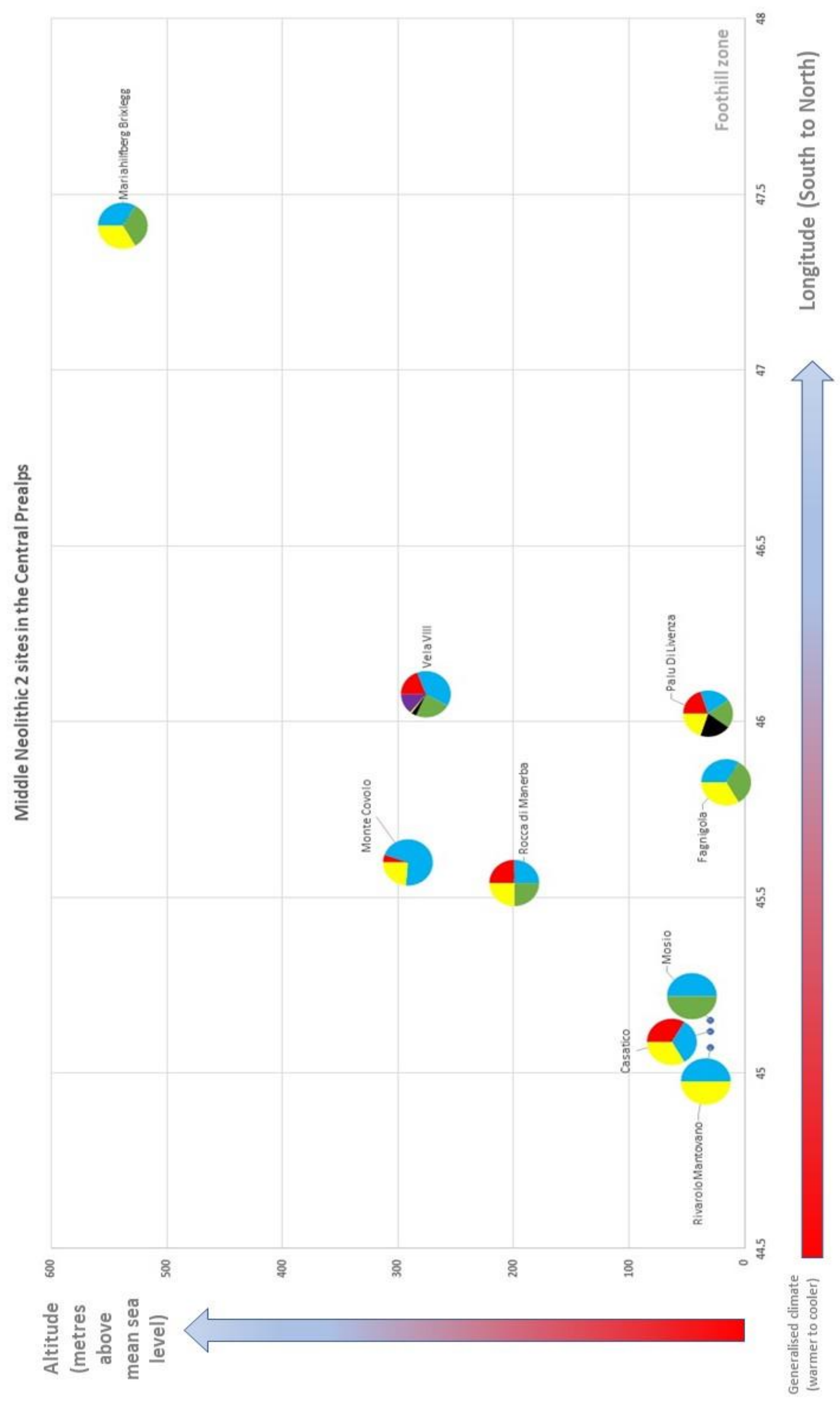


FIGURE 33. THE ALTITUDINAL DISTRIBUTION OF MIDDLE NEOLITHIC 2 SITES IN THE CENTRAL ALPS AND NORTHERN ITALY.

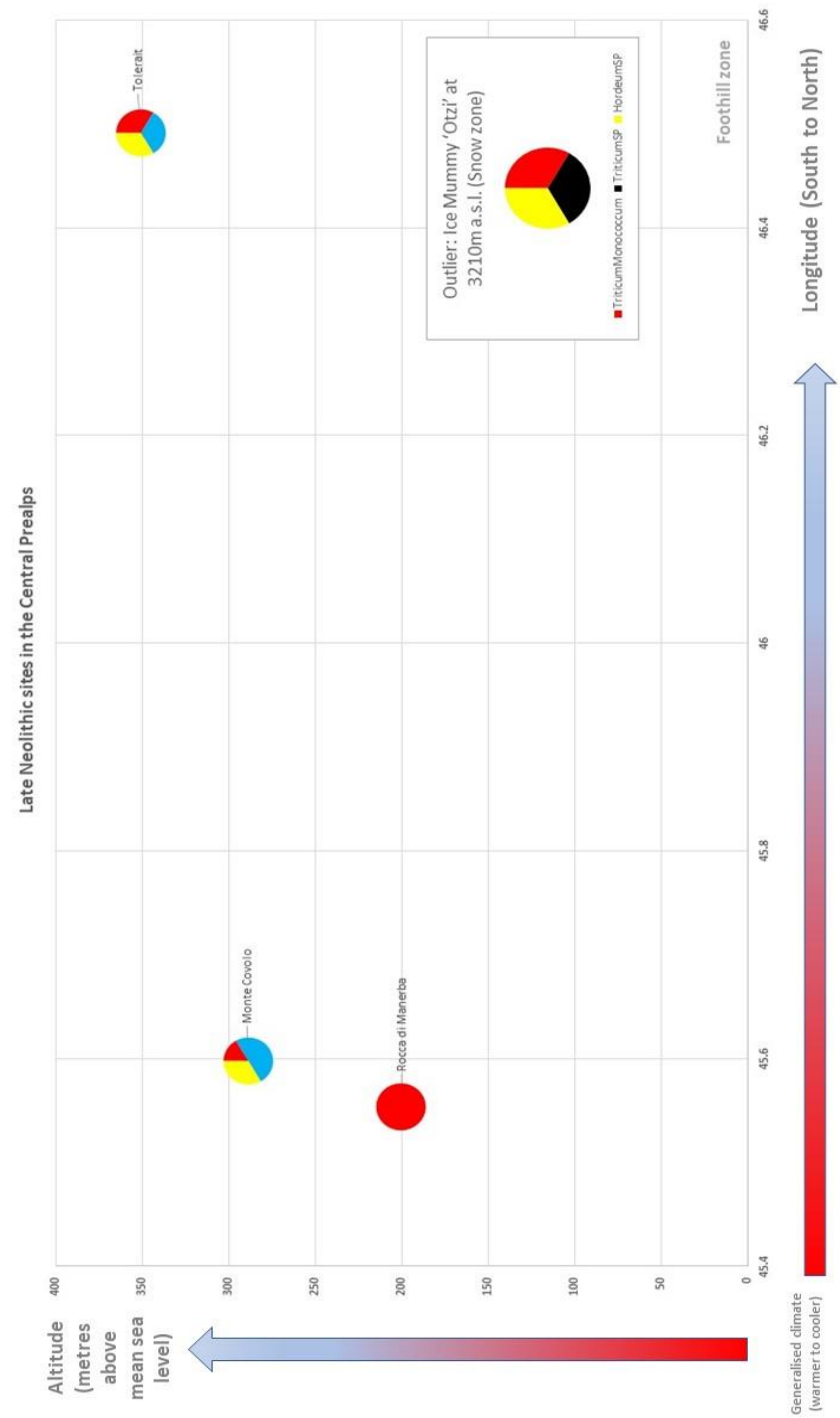


FIGURE 34. THE ALTITUDINAL DISTRIBUTION OF LATE NEOLITHIC SITES IN THE CENTRAL ALPS AND NORTHERN ITALY.

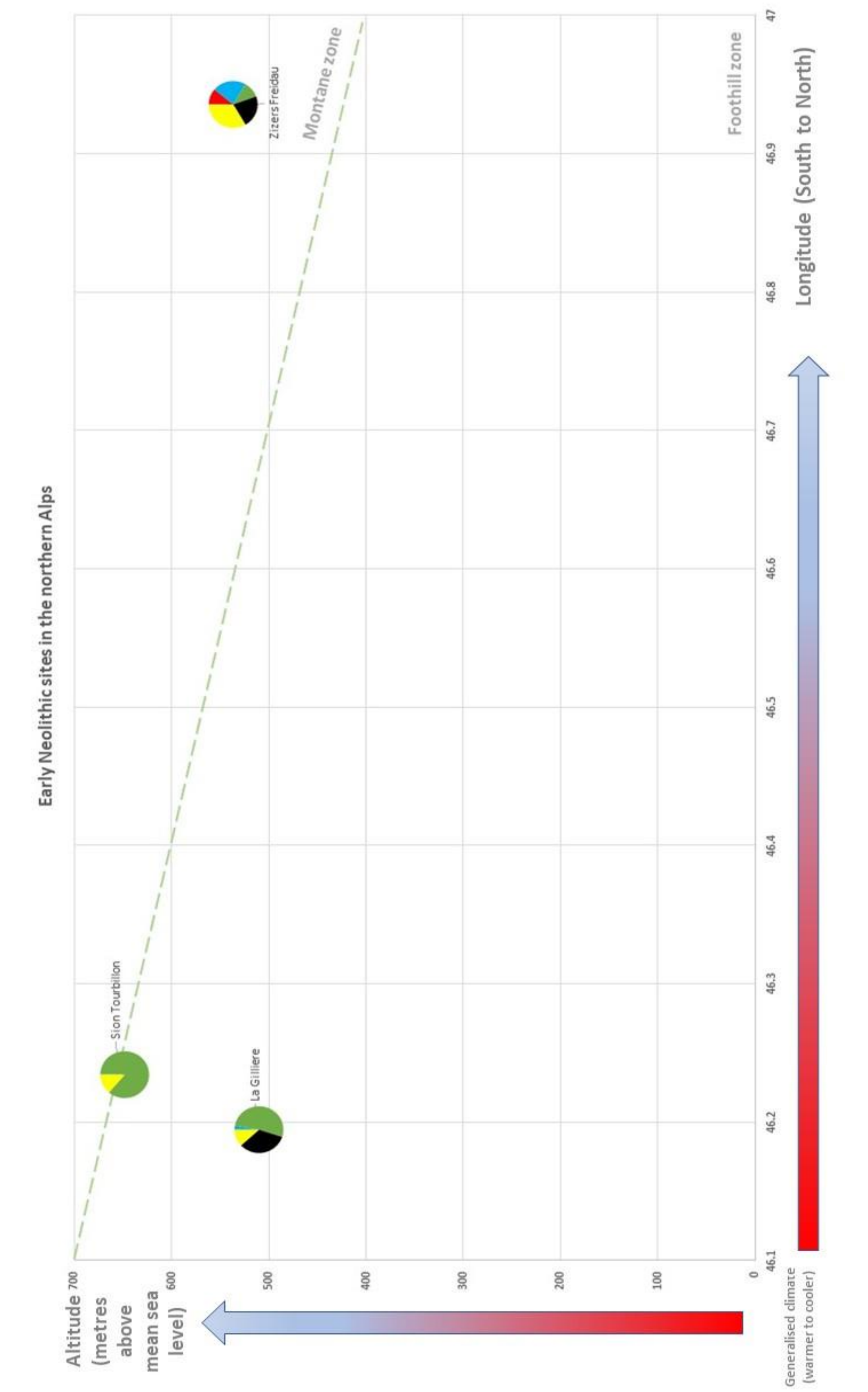


FIGURE 35. THE ALTITUDINAL DISTRIBUTION OF EARLY NEOLITHIC SITES IN THE NORTHERN ALPS.

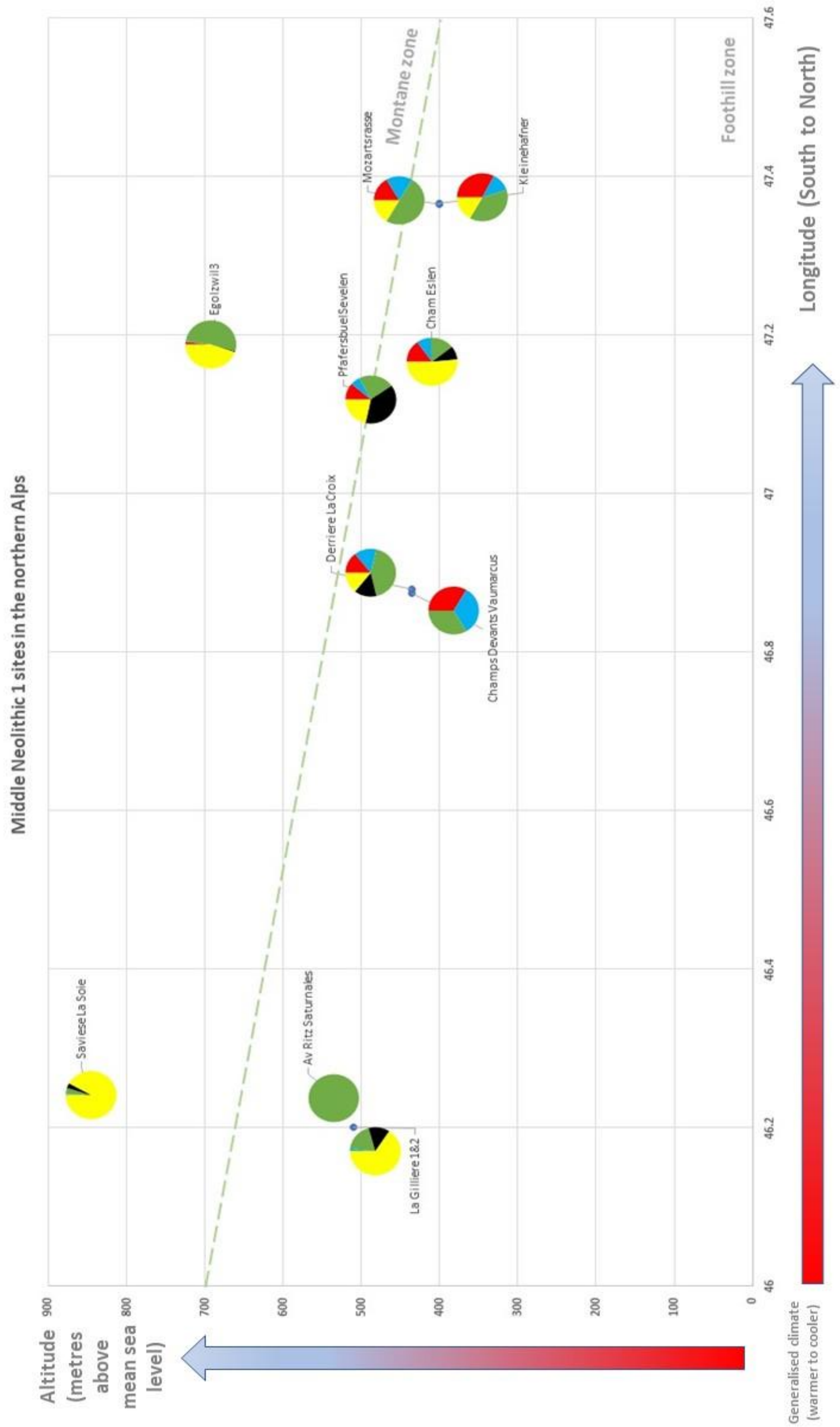


FIGURE 36. THE ALTITUDINAL DISTRIBUTION OF MIDDLE NEOLITHIC 1 SITES IN THE NORTHERN ALPS.

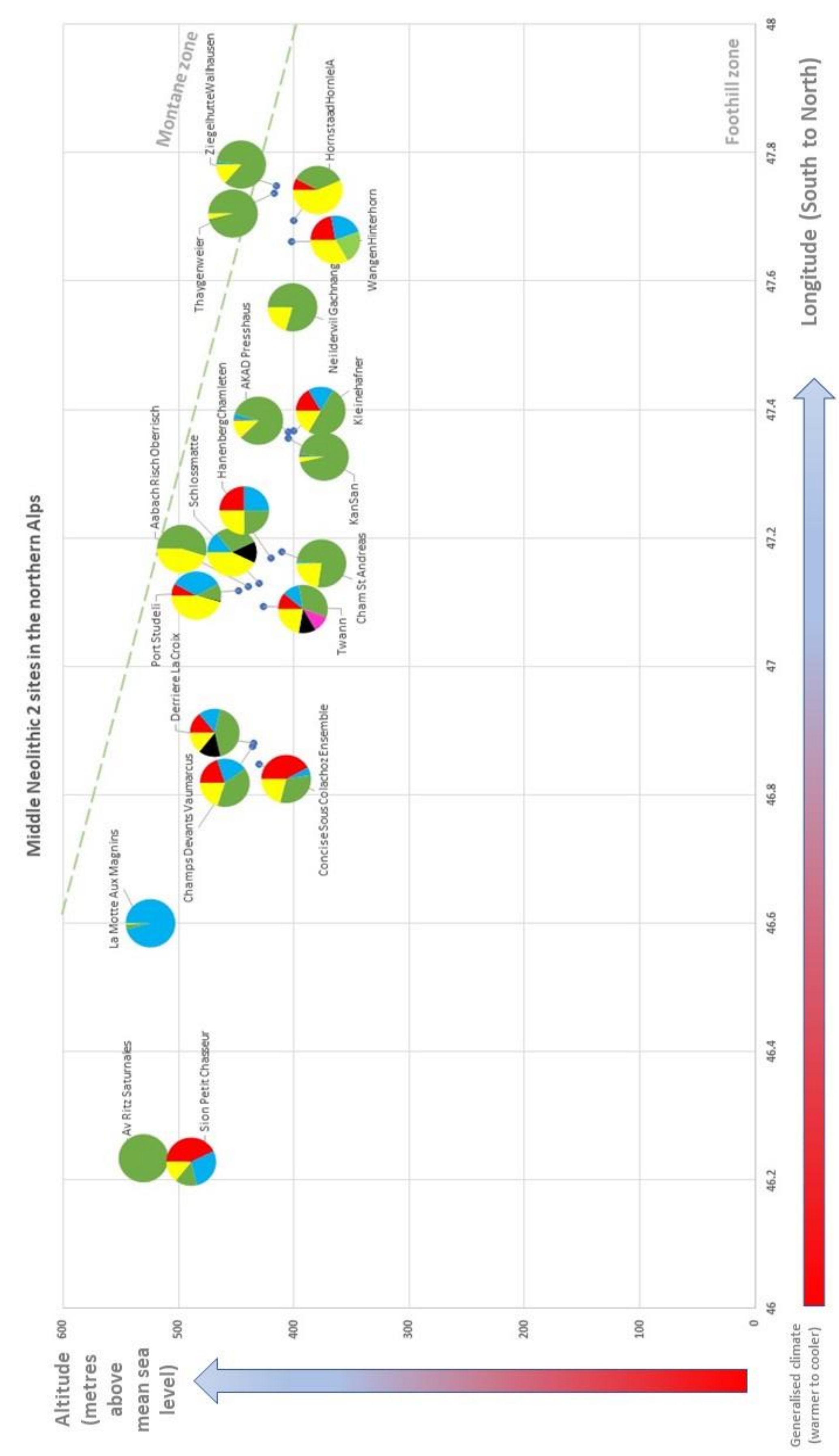


FIGURE 37. THE ALTITUDINAL DISTRIBUTION OF MIDDLE NEOLITHIC 2 SITES IN THE NORTHERN ALPS.

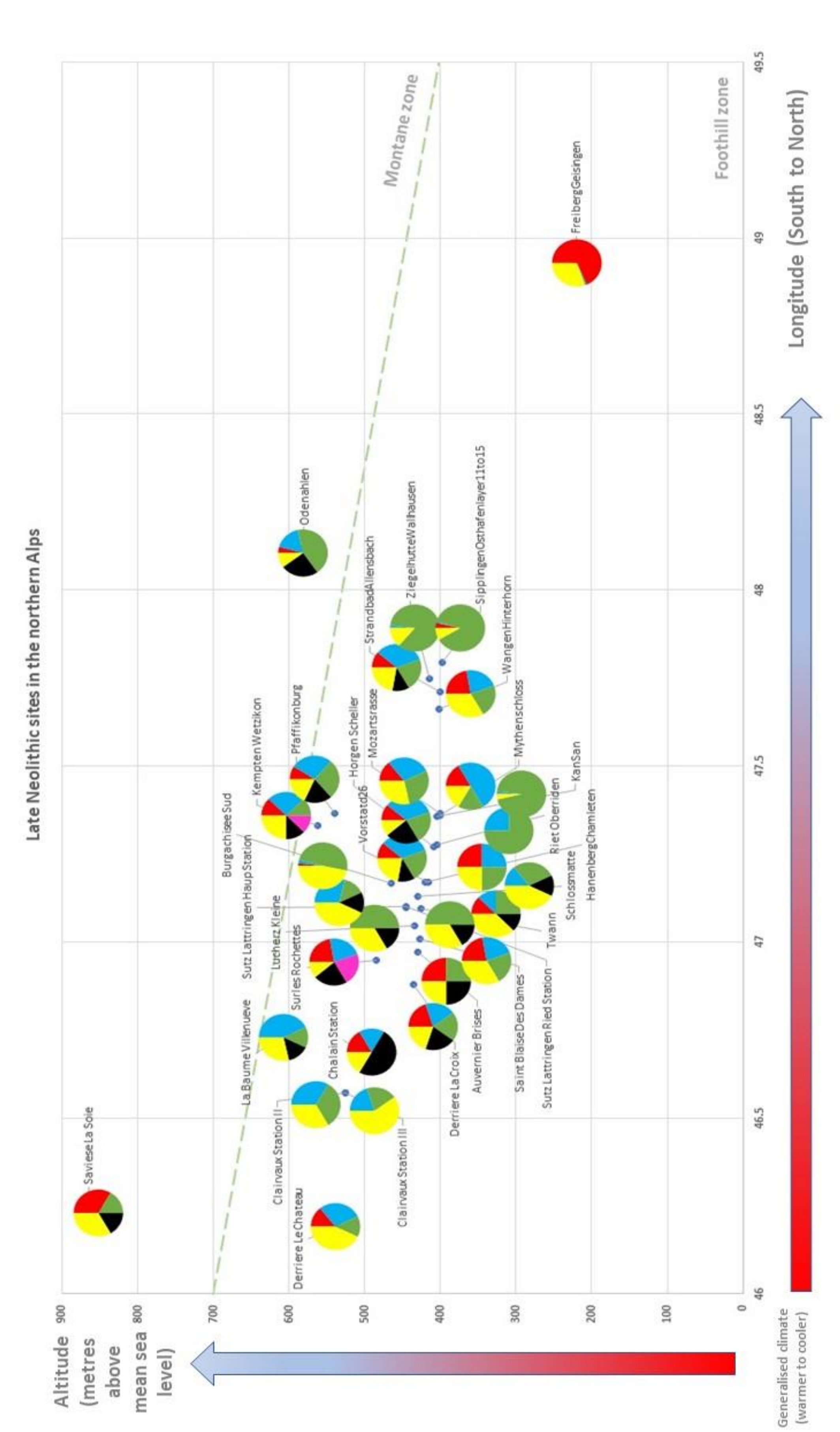


FIGURE 38. THE ALTITUDINAL DISTRIBUTION OF LATE NEOLITHIC SITES IN THE NORTHERN ALPS.

A.3. Appendix 3: Figures illustrating non-cereal crop distribution

The following figures display a spatial representation of the distribution and frequency of non-cereal staple crop macrofossils across the Alps throughout the Neolithic. The crops represented are *Pisum sativum*, *Lens culinaris*, *Linum usitatissimum*, and *Papaver somniferum*, and are presented on maps covering the entire study area. The remains are represented semi-quantitatively according to their frequency, as absent, present, common, or abundant, to standardise the dataset in which both semi-quantitative and quantitative data was used. These figures are referred to in Chapter 4.

Pisum sativum

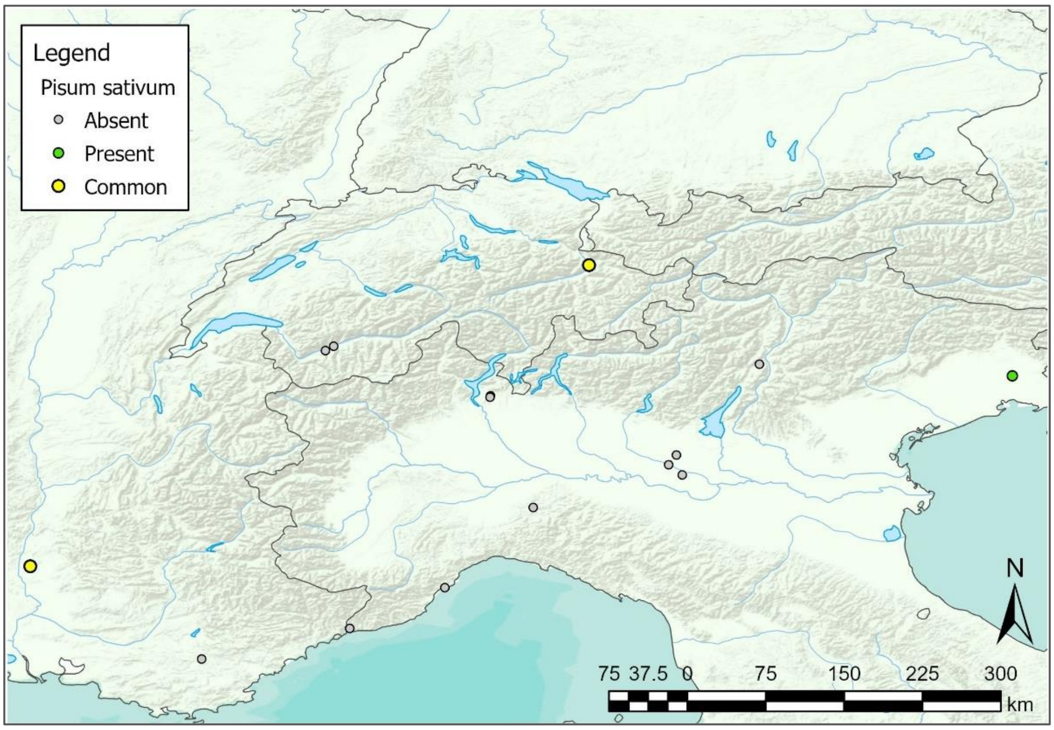


FIGURE 39. DISTRIBUTION OF PISUM SATIVUM IN THE EARLY NEOLITHIC ACROSS THE ALPS.

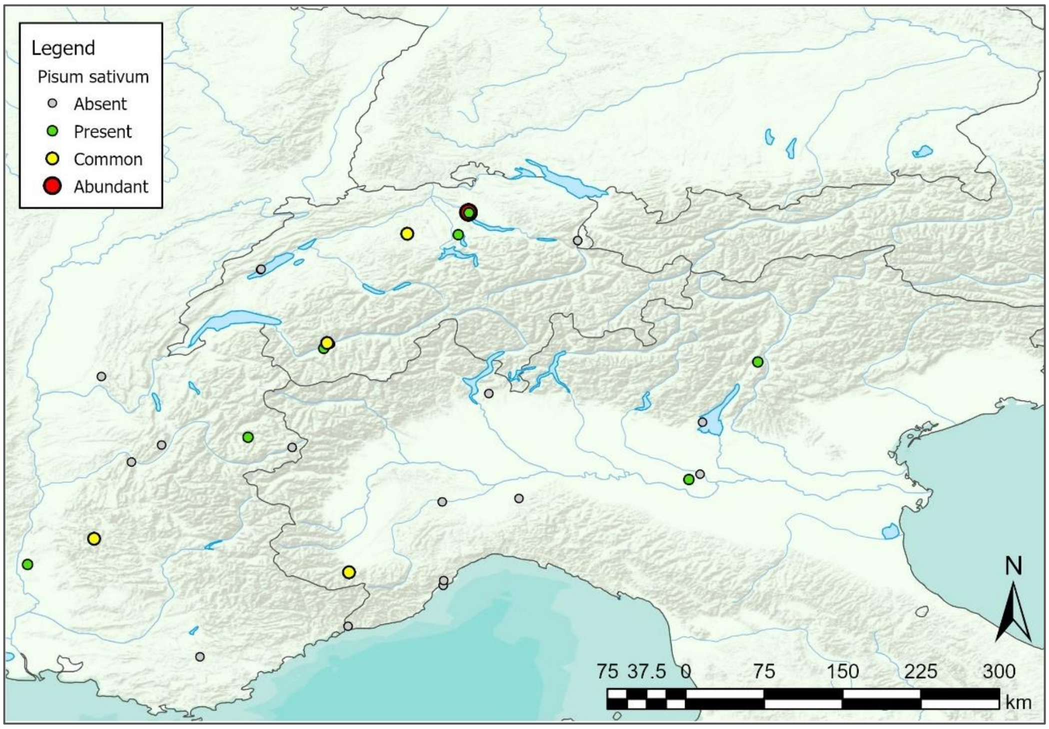


Figure 40. Distribution of Pisum sativum in the Middle Neolithic 1 across the Alps.

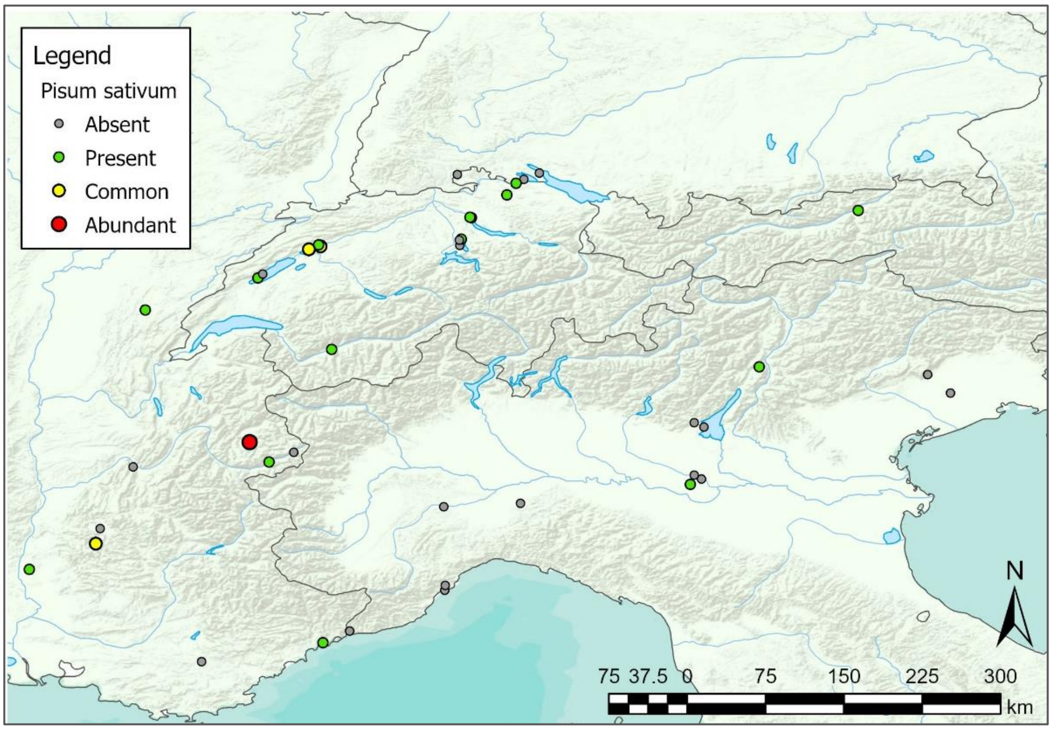


Figure 41. Distribution of Pisum sativum in the Middle Neolithic 2 across the Alps.

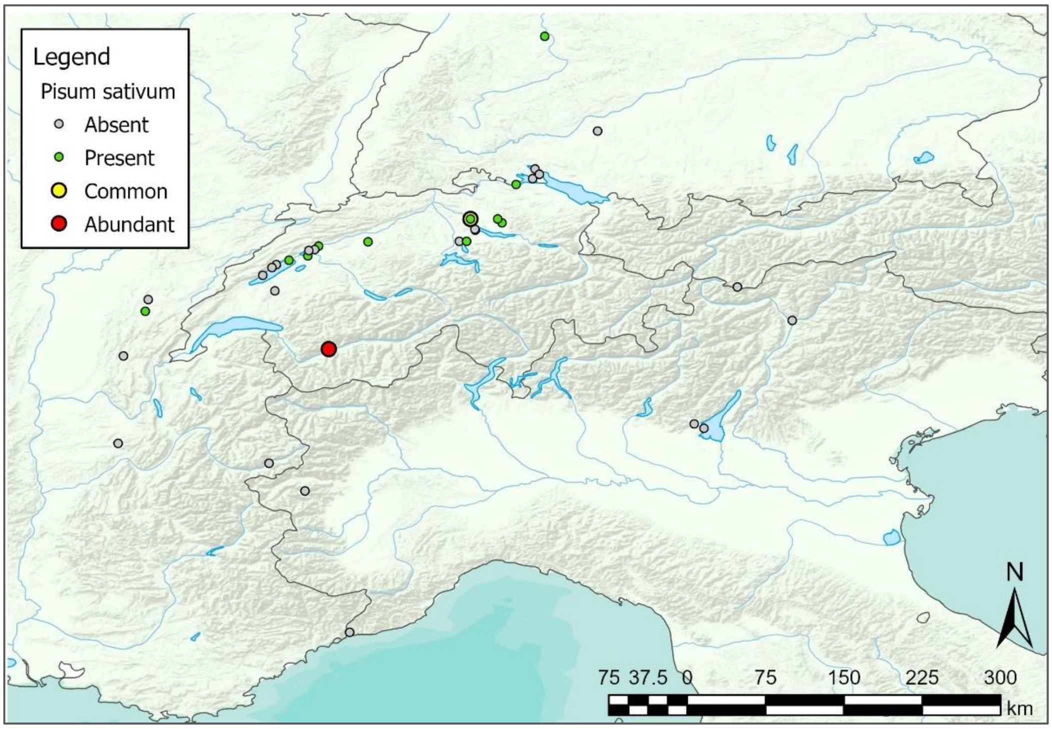


FIGURE 42. DISTRIBUTION OF PISUM SATIVUM IN THE LATE NEOLITHIC ACROSS THE ALPS.

Lens culinaris

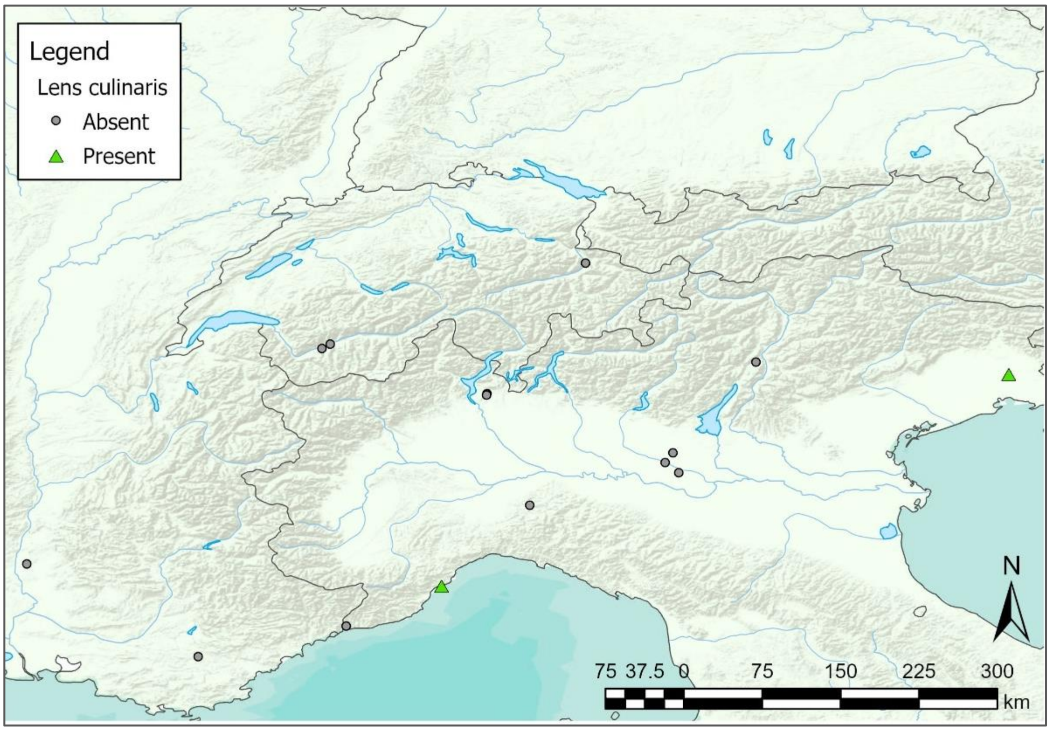


FIGURE 43. DISTRIBUTION OF LENS CULINARIS IN THE EARLY NEOLITHIC ACROSS THE ALPS.

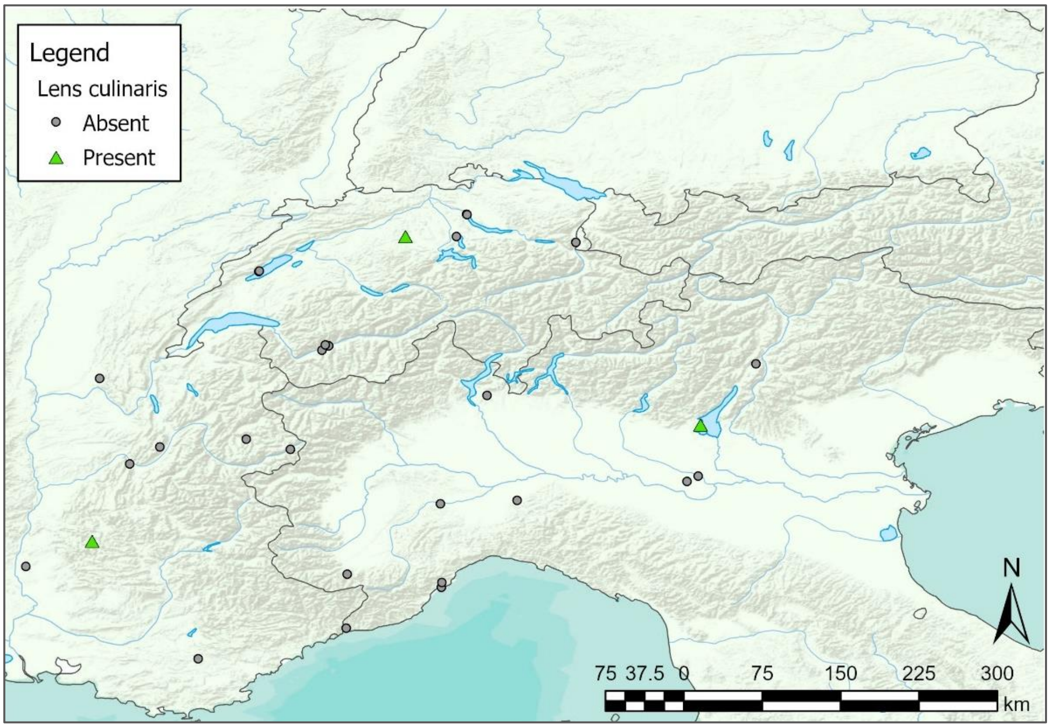


FIGURE 44. DISTRIBUTION OF LENS CULINARIS IN THE MIDDLE NEOLITHIC 1 ACROSS THE ALPS.

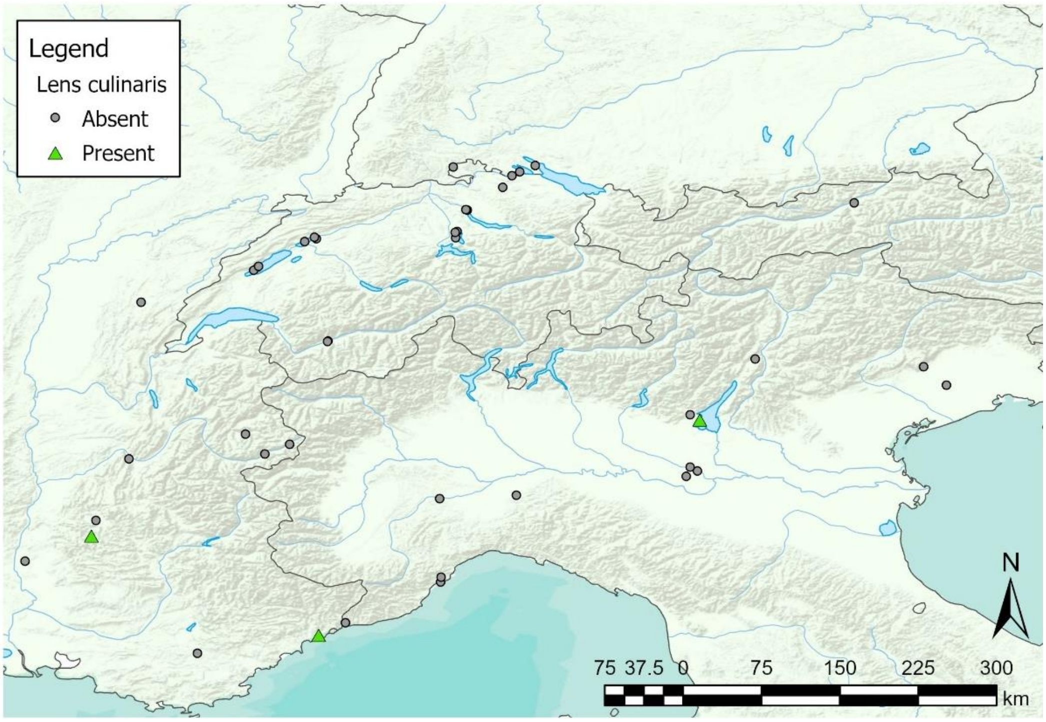


FIGURE 45. DISTRIBUTION OF LENS CULINARIS IN THE MIDDLE NEOLITHIC 2 ACROSS THE ALPS.

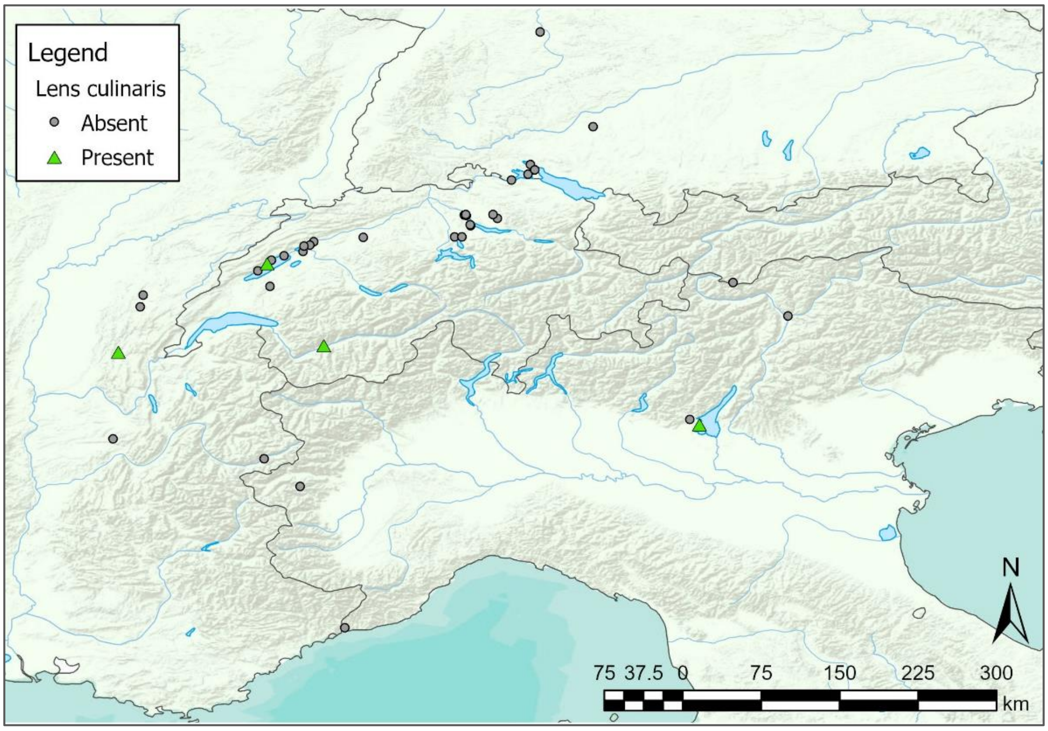


FIGURE 46. DISTRIBUTION OF LENS CULINARIS IN THE LATE NEOLITHIC ACROSS THE ALPS.

Linum usitatissimum

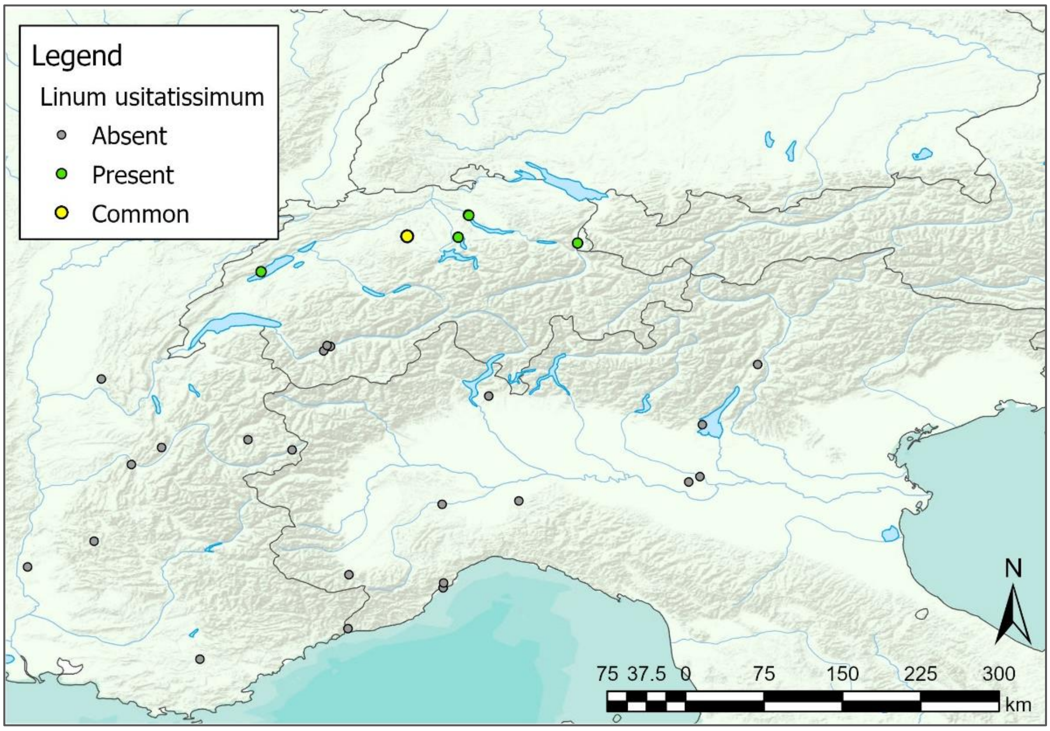


FIGURE 47. DISTRIBUTION OF LINUM USITATISSIMUM IN THE MIDDLE NEOLITHIC 1 ACROSS THE ALPS.

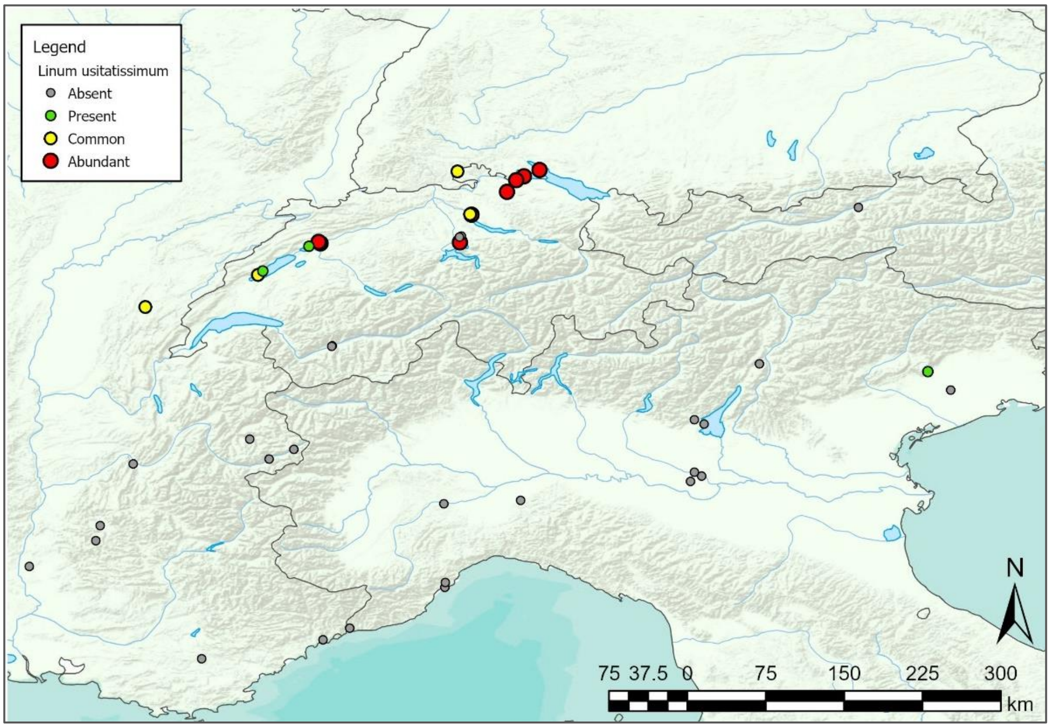


FIGURE 48. DISTRIBUTION OF LINUM USITATISSIMUM IN THE MIDDLE NEOLITHIC 2 ACROSS THE ALPS.

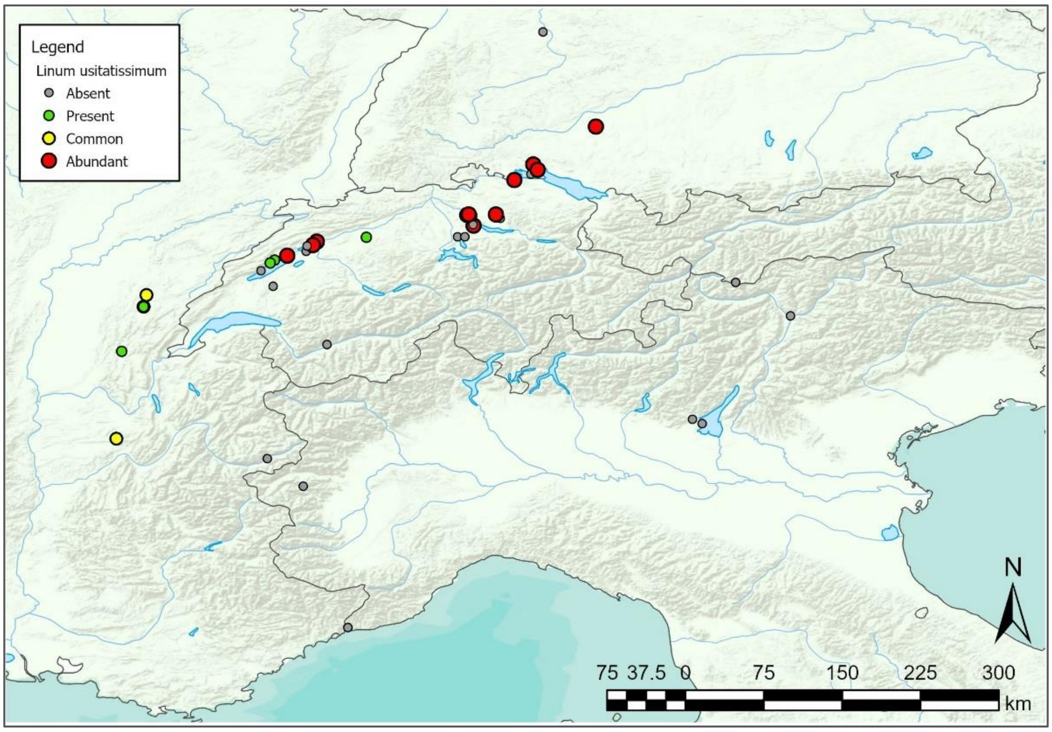


FIGURE 49. DISTRIBUTION OF LINUM USITATISSIMUM IN THE LATE NEOLITHIC ACROSS THE ALPS.

Papaver somniferum

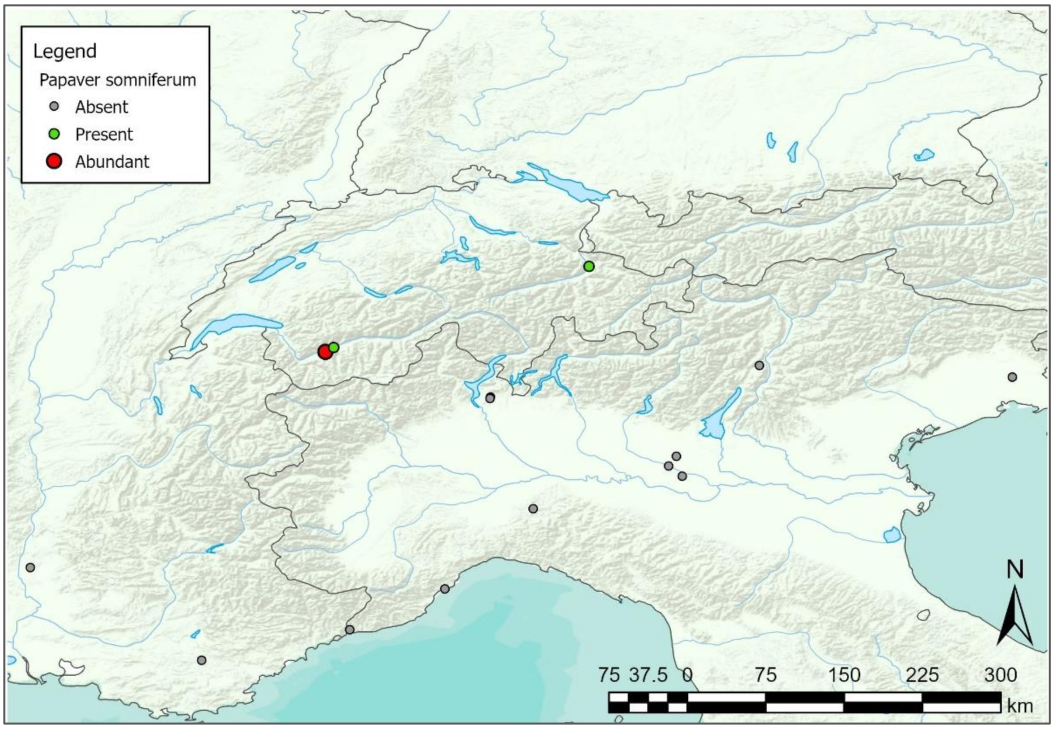


FIGURE 50. DISTRIBUTION OF PAPAVER SOMNIFERUM IN THE EARLY NEOLITHIC ACROSS THE ALPS.

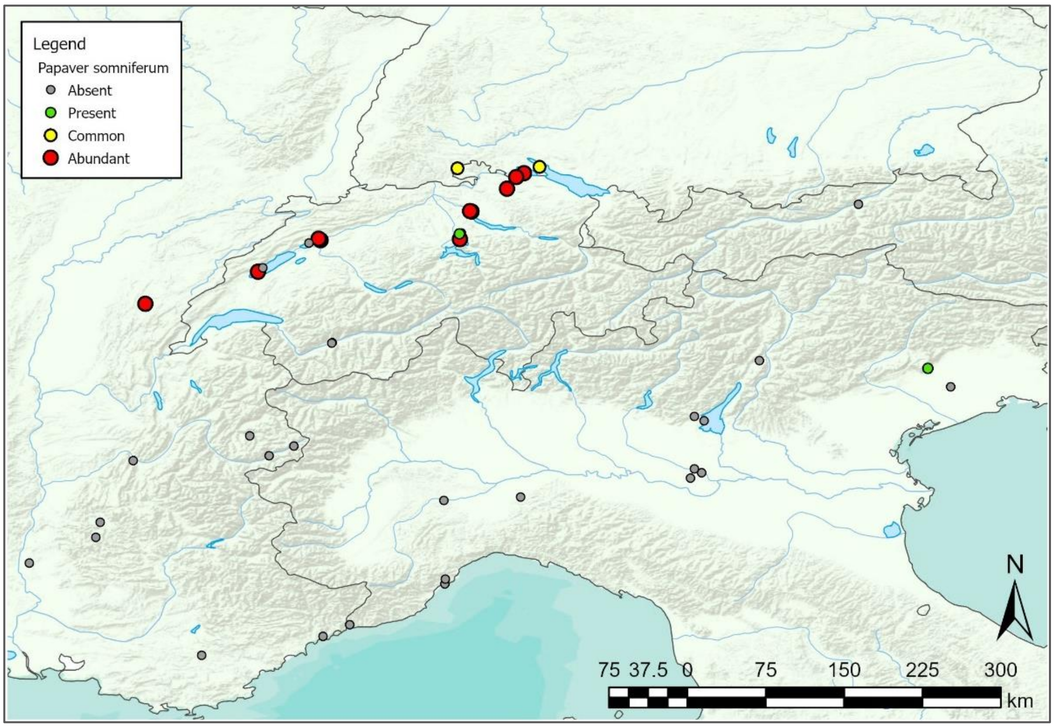


FIGURE 51. DISTRIBUTION OF PAPAVER SOMNIFERUM IN THE MIDDLE NEOLITHIC 1 ACROSS THE ALPS.

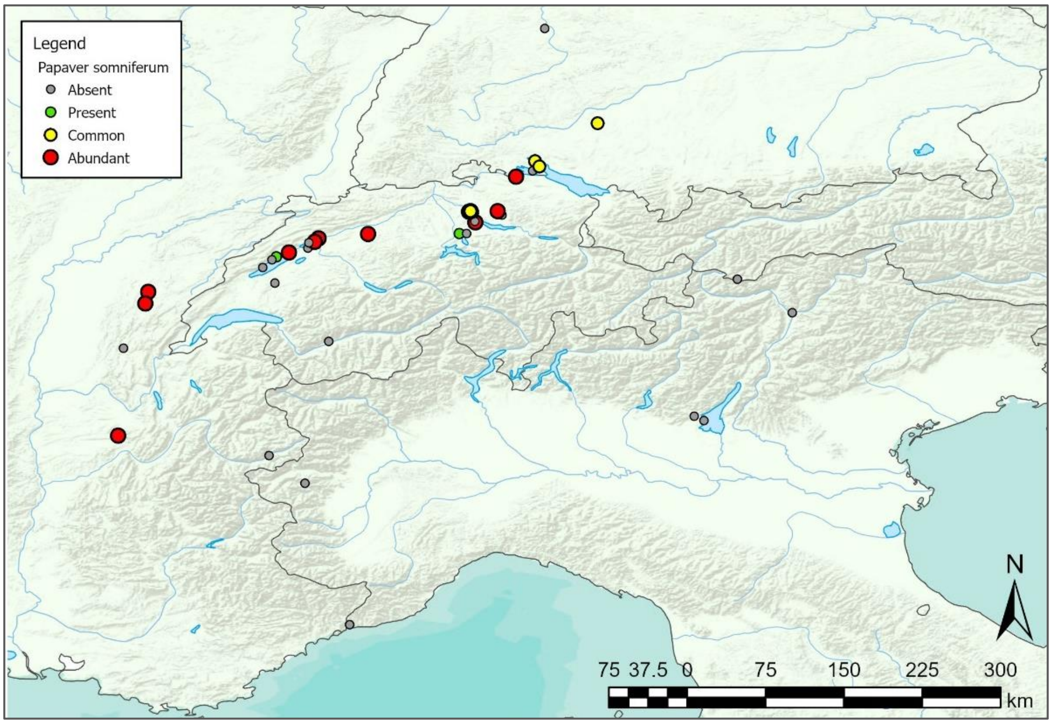


FIGURE 52. DISTRIBUTION OF PAPAVER SOMNIFERUM IN THE MIDDLE NEOLITHIC 2 ACROSS THE ALPS.

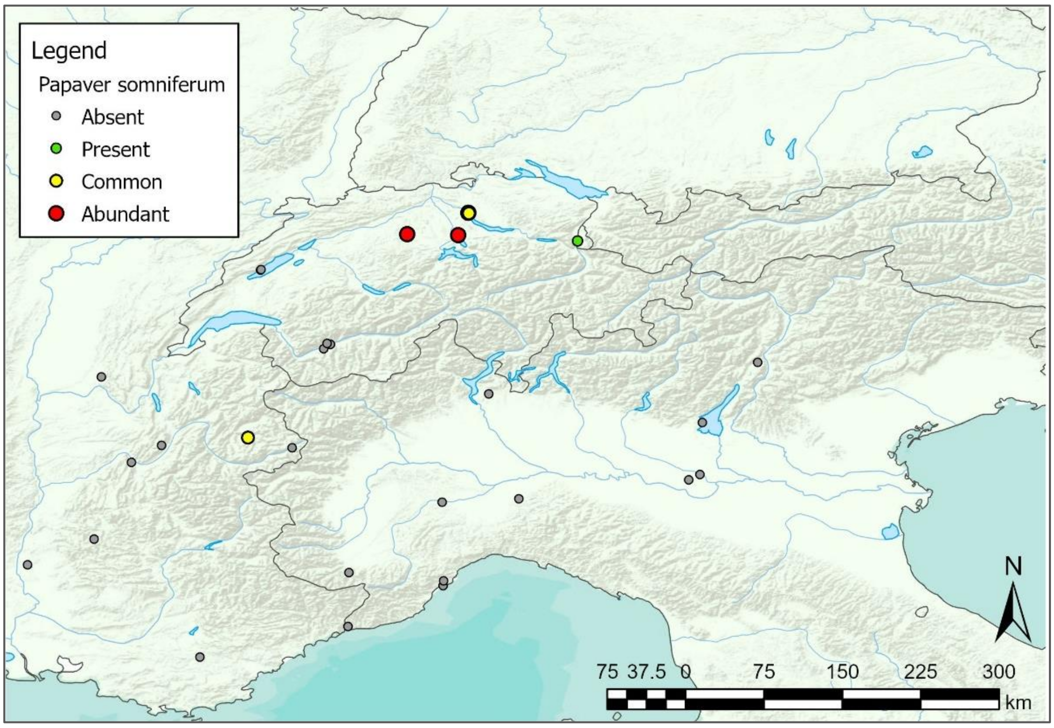


FIGURE 53. DISTRIBUTION OF PAPAVER SOMNIFERUM IN THE LATE NEOLITHIC ACROSS THE ALPS.

A.4. Appendix 4: Radiocarbon dates and the character of occupation layers at Trou Arnaud.

A summary of the character of the stratigraphic phases, including occupation layers, and their associated radiocarbon dates is presented in Table 1, abridged from the site report by Daumas & Laudet (1998). Three to four successive phases of temporary occupation of varying intensity were identified, in which material culture is consistent with the Ancient Chasséen.

Table 5. Occupation layers at Trou Arnaud and their related radiocarbon dates (after Daumas & Laudet, 1998).

Layer	Mean calibrated radiocarbon date (and potential range)	Character
A	4040 BC (4299-3940 BC)	Occupation layer, concentrated towards the cave entrance. Limited ceramic, lithic and bone material clustered towards the walls of the cave and no structural remains. Often difficult to distinguish from Layer B.
B	4197 BC (4335-3986 BC)	Layer relates to the main occupation of the site. Abundant archaeological material as lithics, human and animal bone, and ceramics, concentrated towards the walls of the cave. Multiple structures and hearths identified.
E	4361 BC (4648-4144 BC)	Occupation layer. Remains of several clay structures interpreted as storage areas or silos and abundant ceramic material. One raw clay structure persists until the formation of Layer B.
G	4460 BC (4623-4352 BC)	First occupation layer. Traces of combustion in concentrated areas and structural remains in the form of multiple, successive stake holes. Interpreted as a fleeting occupation with a storage function.
C, D and F	N/A	Sterile layers. No trace of human occupation.
Galerie des Pots	Unknown – but suggested as contemporaneous to layer B.	Abundant ceramic, lithic, bone and organic material. Many more seeds than in the excavated layers, thus likely a storage place. Concentrated burning towards the entrance of the gallery, weakening towards the interior.

A.5. Appendix 5: Plans and sections from sampled contexts at Trou Arnaud

The following figures present site plans or sections from layers at Trou Arnaud sampled during the excavations in the 1980s by Daumas & Laudet (1998): these are Layer E, Layer B, and the internal stratigraphy of the clay vessel in square I3/4. The layers are divided by a grid, in which each square is represented by a letter along the horizontal axis, and number along the vertical axis. Samples were numbered according to the square and stratigraphic layer from which they were collected. All figures are redrawn and translated versions of drawings presented in the first volume of the site report from Trou Arnaud (Daumas & Laudet, 1998). The samples represented in each layer are listed in the captions for each drawing. The Galerie des Pots is not depicted in these figures, due to being sampled in earlier excavations for which site reports were not published, but lies to the north beyond the excavated area.

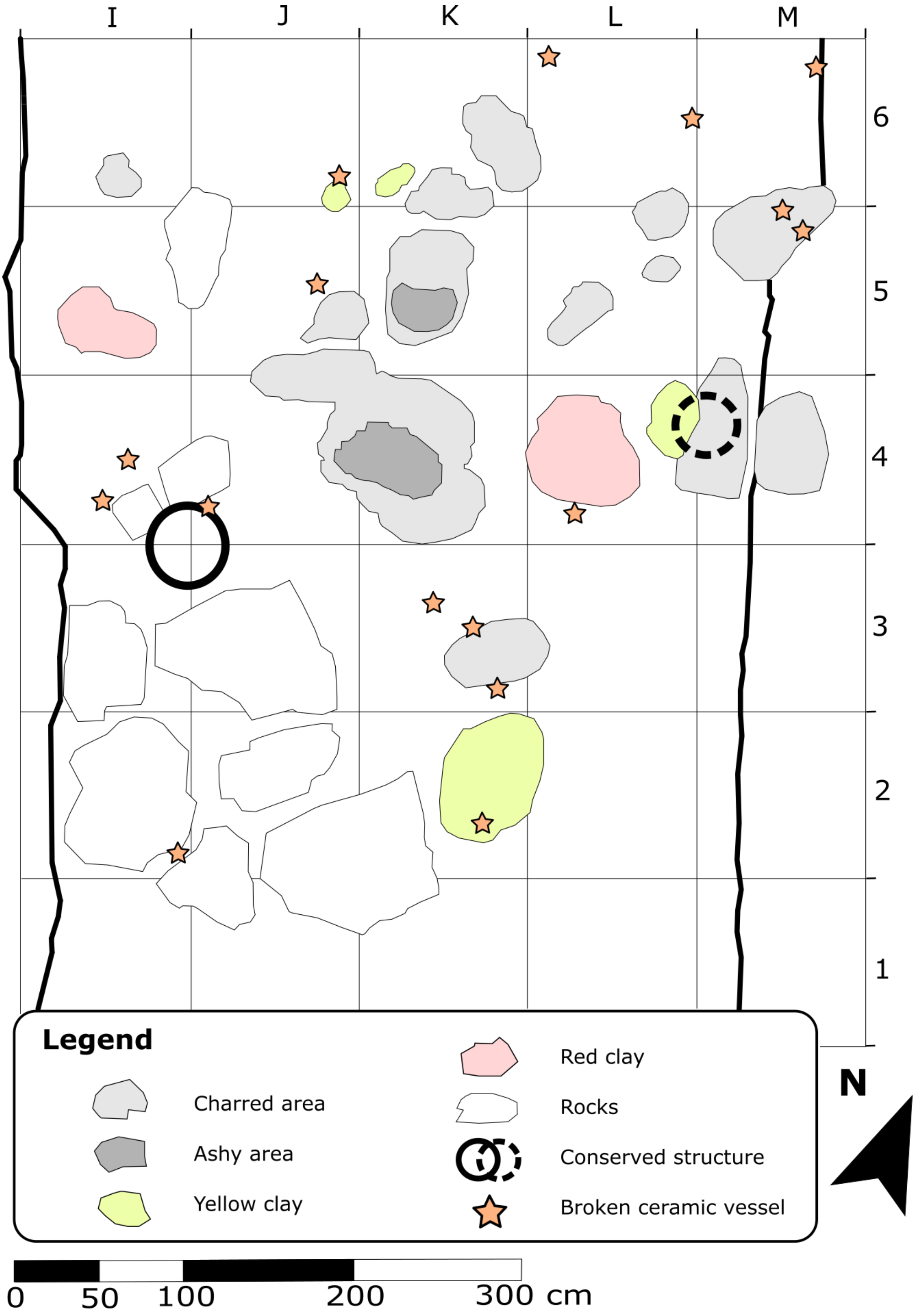


FIGURE 54. SITE PLAN FROM LAYER E (4648-4144 BC). THE SAMPLED SQUARES INCLUDE: M5 NO.1923, AND INTERNAL LEVEL 3 FROM THE CLAY STRUCTURE IN I3.

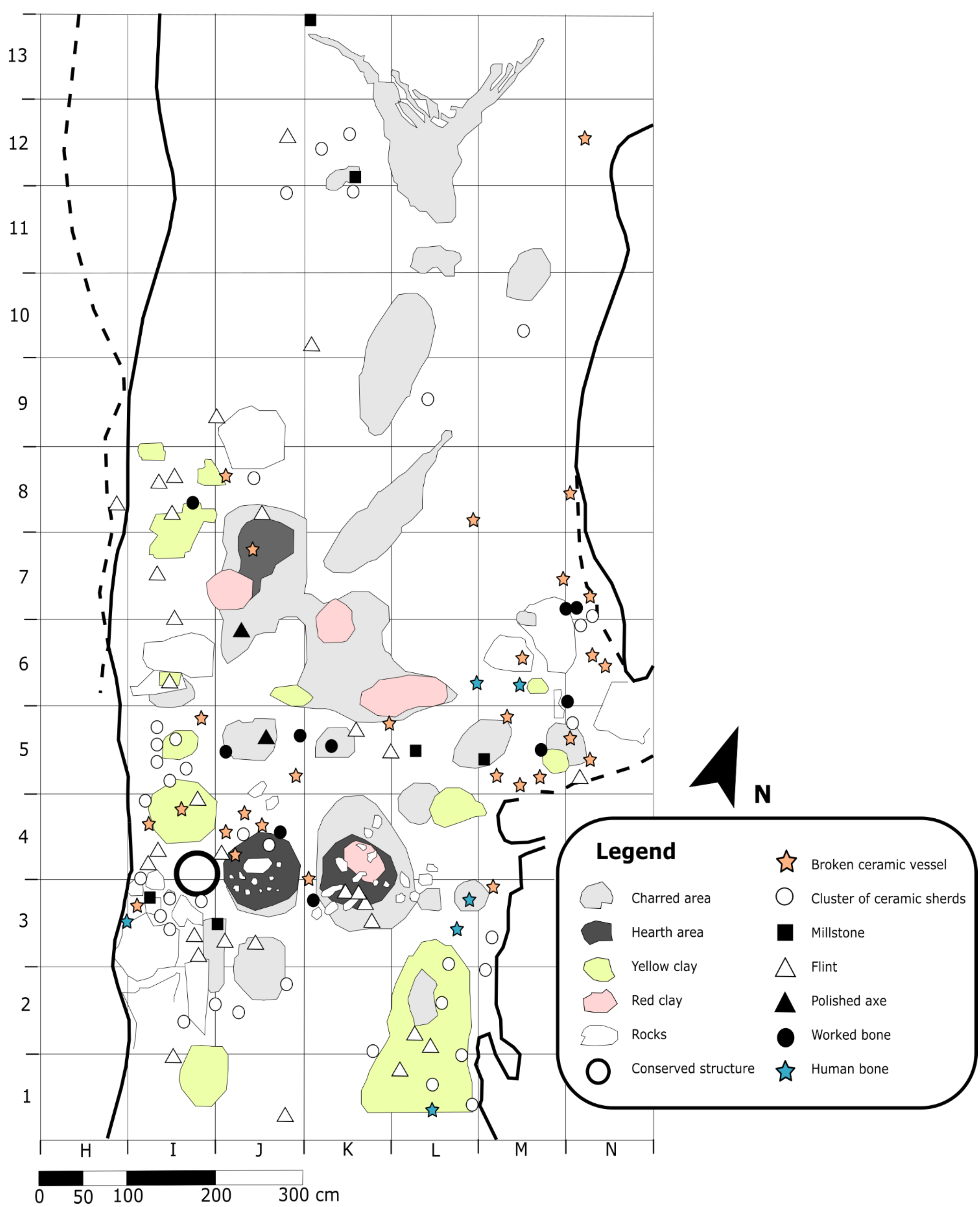


FIGURE 55. SITE PLAN FROM LAYER B (4335-3986 BC). THE SAMPLED SQUARES INCLUDE: I3 INTERNAL LEVELS 1-2 FROM CLAY VESSEL, I3B, I4B, I4BC, I7B – HEARTH, J3B, J4B – HEARTH, J4-K4B – HEARTH, J7-J2B – HEARTH, K3B – HEARTH, K6B, L1B, L2B, L6B.

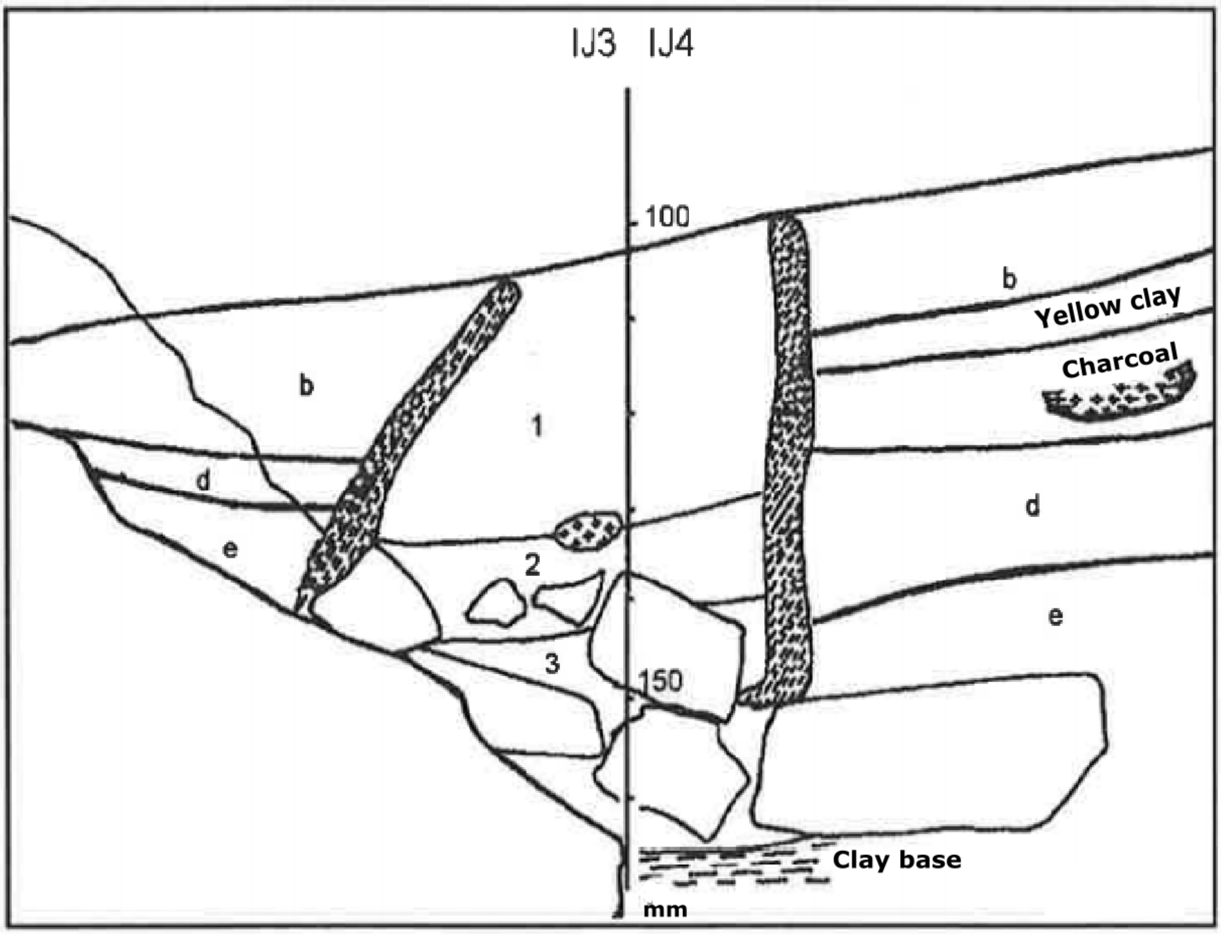


FIGURE 56. SECTION DRAWING OF THE CLAY VESSEL IN SQUARES I3/4. SAMPLED LAYERS INCLUDE: I3 INTERNAL LEVEL 1-2 (ATTRIBUTABLE TO LAYER B), AND I3 INTERNAL LEVEL 3 (ATTRIBUTABLE TO LAYER E).

A.6. Appendix 6: Quantification of plant macrofossils from Trou Arnaud

Two tables are presented in this appendix relating to the original quantification of macrofossils from Trou Arnaud. These are referred to in Chapter 5 during the discussion of the case study. Firstly, a count of identified taxa is included in Table 6, followed by Table 7 detailing the rates of fragmentation per context. The rates of fragmentation per taxon are presented in the Catalogue of Taxa in Appendix 7. Each taxon has been counted and recorded by context, and for each entry the identification is specified alongside the plant part recovered. Taxa have also been separated into categories: crop plants and cultivated flora, arable and ruderal weeds, and wild taxa.

TABLE 6. THE COMPLETE QUANTIFICATIONS OF MACROFOSSILS FROM TROU ARNAUD IDENTIFIED DURING THIS ANALYSIS ARE PRESENTED IN THE FOLLOWING TABLE.

Context (square) number	Galerie des Pots	M5 no.1923 I	M7b	K3b – hearth	J4-K4b – hearth	I3 level 1-2	I3 level 3 – silo	K6b	L1b	L6b	L2b	I4b	I3b	I4bc	I7b – hearth	J7-J2 – hearth	J3b	J4b	Total
Crop plants and cultivated flora																			
Cerealia type, grain	110	.	.	32	20	1	4	.	.	2	8	3	.	.	24	32	.	.	236
Triticum sp., grain	229	.	.	19	3	3	5	1	.	1	14	5	1	.	25	37	.	4	347
Triticum sp., glume	13	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	14
Hordeum vulgare, grain	45	200	.	44	21	.	2	1	.	2	10	7	.	.	6	26	.	107	471
cf. *Hordeum* sp., grain	22	55	.	11	1	.	.	.	.	.	4	4	.	.	7	9	.	3	116
Triticum monococcum, grain	1643	.	.	56	.	1	3	.	.	.	11	3	5	.	12	30	.	2	1766
T. cf. *monococcum*, grain	370	.	.	2	.	.	.	.	1	3	4	5	.	.	.	12	.	.	397
T. cf. *monococcum*, spikelet fork	14	.	.	2	.	.	.	.	.	.	.	1	.	.	.	.	.	.	17
Triticum dicoccum, grain	574	1	.	13	2	1	1	.	.	3	3	5	3	.	9	30	.	2	647
Triticum cf. *dicoccum*, grain	406	1	2	6	.	.	1	.	.	.	3	1	.	1	3	15	.	.	439
Triticum cf. *dicoccum,* spikelet fork	5	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6
Triticum monococcum/dicoccum, grain	156	.	.	.	.	1	.	.	.	.	1	.	.	.	.	5	.	.	163
Triticum aestivum/durum/turdigum, grain	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
Triticum. Cf. *aestivum/durum/turdigum*, grain	19	.	.	1	.	.	3	.	.	.	5	3	.	.	1	4	.	.	36
Triticum dicoccum/aestivum/durum/turdigum, grain	52	.	.	.	.	.	.	.	.	.	11	.	1	.	2	1	.	.	67
Triticum dicoccum/spelta, grain	12	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	13
Total cereal – grains	3641	257	2	184	47	7	19	2	1	11	74	36	10	1	89	202	.	118	4701
Total cereal – glume bases or glumes	32	.	.	4	.	.	.	.	.	.	.	1	.	.	.	.	.	.	37
Pisum sativum, grain	8	1	.	4	64	6	6	.	1	.	3	2	1	3	4	5	.	221	329
cf. *Pisum sativum*, grain	.	.	.	1	5	.	.	.	.	.	.	.	.	.	.	1	.	13	20
Lens culinaris, grain	.	.	.	2	6	.	1	.	.	.	.	.	.	.	2	2	.	58	71
cf. *Lens culinaris*, grain	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	1	.	2	5
Arable and ruderal weeds																			
Poaceae sp., seed	17	.	.	.	.	.	.	.	.	.	.	1	.	.	.	2	.	.	20
Poaceae/Lamiaceae, seed	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1
Bromus sp., seed	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	13
Chenopodium cf. *album*, seed	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Brassicaceae. Cardamine/Descurania, seed	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	1
cf. *Fabaceae* sp., seed	.	.	.	1	.	.	1	.	.	1	.	.	.	.	.	.	1	.	4
Polygonaceae/Cyperaceae, seed	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1

Rumex cf. *acestosella*, seed		.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Rumex sp., seed		.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1	.	.	2
Ranunculus sp., seed		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1
Rubus idaeus/fruticosus, seed		.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1
cf. *Rubus* sp., seed		.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Galium sp., seed		.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Wild taxa																				
Inconclusive, cf. *Juniperus*, cone?		.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	1
Abies sp., needle		2	.	.	.	1	.	.	.	.	.	.	10	.	.	.	.	.	.	13
cf. *Quercus* sp., tree leaf bud		.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1
cf. *Fraxinus excelsior*, key		1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Tree leaf bud		.	.	.	.	.	.	1	.	.	.	1	.	.	.	.	.	.	.	2
Ignota (whole seeds)		3	.	1	.	3	.	.	1	.	1	.	.	.	.	.	.	.	.	9
Total charred remains (excluding ignota)		3711	260	2	196	129	13	28	2	2	12	79	52	11	4	96	219	1	412	5229

A.7. Appendix 7: Catalogue of taxa

A catalogue of the identified plant macrofossils from Trou-Arnaud has been provided in this Appendix. These are listed by family, following the order and nomenclature of *Flora Gallica* (Tison & de Foucault, 2014). Taxa have been described and measured in cases in which whole seeds have been recovered, and solely described if remains were only recovered as fragments. Macrofossils have been measured to an accuracy of 100 microns using a calibrated digital vernier calliper. Measurements for the length (L), breadth (B), and height (H) of seeds are presented in millimetres (see figure 57), and also the measurements of identifying morphological characteristics of spikelet forks (see figure 58). The mean average of each measurement (L, B, and H), alongside the minimum and maximum values, have been presented. The rate of fragmentation is also presented as the percentage of macrofossils represented by fragmentary remains through a count of the minimum number of individuals.

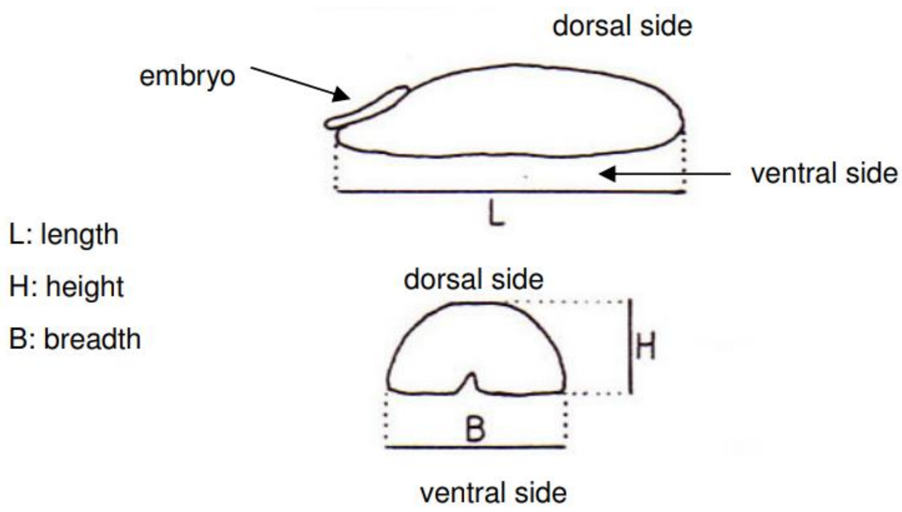


FIGURE 57. MEASUREMENT POINTS FOR CARYOPSES (JACOMET, 2006B).

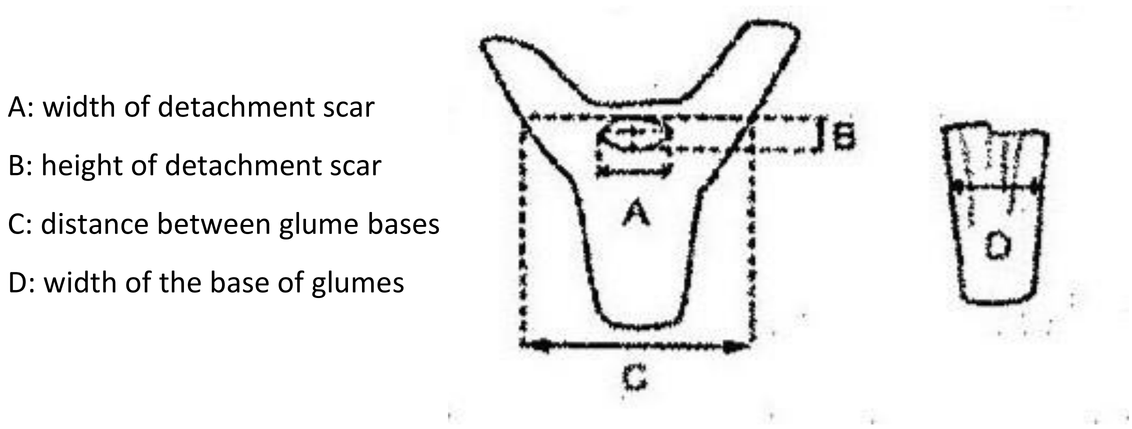


FIGURE 58. MEASUREMENT POINTS FOR CEREAL SPIKELET FORKS (MARTIN, 2014).

A7.1. Crops and cultivated plants

Poaceae

Hordeum vulgare L. subsp. *vulgare/*subsp. *distichon (L.) Körn.*
Vernacular name – domestic barley

Caryopses -
Number measured: 167. L: 4.95 (3.67-6.95). B: 3.07 (1.8-4.09). H: 2.39 (1.39-3.56).

471 examples and 116 possible examples of *Hordeum vulgare* were recovered from across 12 contexts, at a rate of 7% and 54.3% individuals represented by fragmented remains respectively. The outlines were rounded ovate to elliptical, with the widest point at the centre and tapered towards the embryo or apex ends. In transversal section the grains are evenly rounded and subcircular to slightly flattened, and the ventral furrow is shallow and wide. The surface patterning was smooth to slightly rugulose. Grains were generally in poor condition, thus it could not be discerned if the naked or hulled forms were represented. Additionally, although some asymmetry was observed, often characteristic of a six-rowed variety, the possibility of distortion through charring could not be excluded, particularly due to their poor preservation.

FIGURE 59. TWO EXAMPLES OF *HORDEUM VULGARE* FROM SQUARE J4B. THESE ARE WELL-PRESERVED IN COMPARISON TO MOST OF THE ASSEMBLAGE.

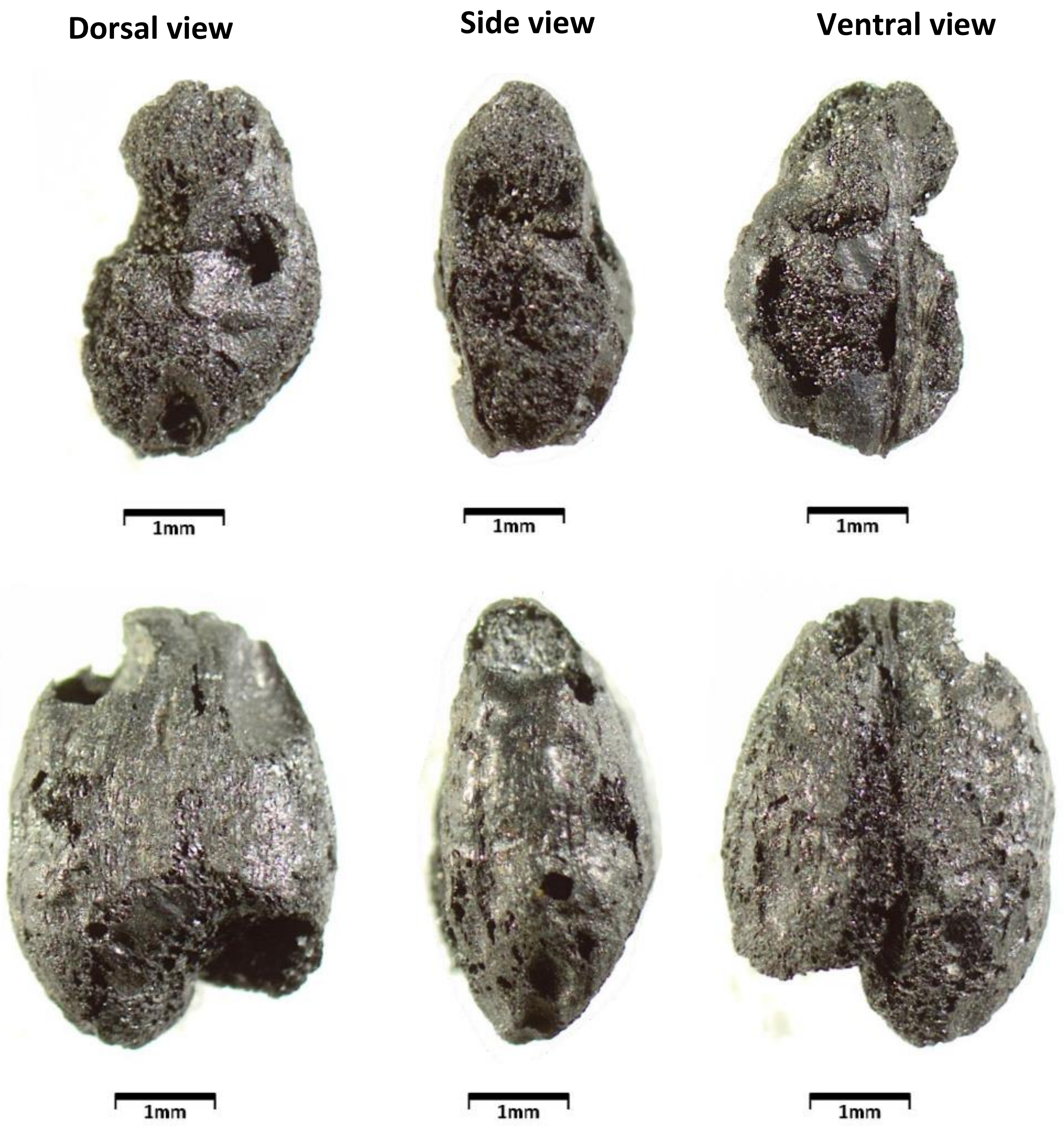


FIGURE 60. TWO EXAMPLES OF RELATIVELY POORLY PRESERVED AND FRAGMENTED HORDEUM VULGARE FROM J4B.

Triticum L.
Vernacular name – wheat

347 examples of *Triticum* sp. were identified across 13 contexts at a rate of 27.6% fragmentation. Many grains display morphological characteristics that overlap numerous species of *Triticum*, thus cannot be confidently attributed to one species, or are poorly preserved and eroded. Caryopses are ovate to oblong-ovate in outline with a flattened ventral surface and deep ventral furrow; surface patterning is usually smooth. 14 detached glumes were also recovered.

T. monococcum L. subsp. *monococcum*
Vernacular name – domestic einkorn wheat

Caryopses -
Number measured: 160. L: 5.16 (3.58-6.28). B: 2.15 (1.28-3.13). H: 2.48 (1.58-3.28)

T. monococcum was the most abundant crop, represented by 1766 examples and 397 possible examples at a rate of 1% and 35.5% fragmentation respectively across 12 contexts. Most caryopses were relatively well preserved, largely intact with limited erosion, alongside fewer degraded and fragmented examples. Caryopses were narrowly ovate to lanceolate and mostly symmetrical in outline, tapered towards a point at both the apex and embryo ends. In side view, these were high backed, with the highest point in the centre, and ventrally convex. Grains in transversal section were not evenly rounded and often subtriangular, with a high, rounded off dorsal ridge, and a deep, narrow ventral furrow. Surfaces were smooth and matte, occasionally with impressions of the glumes as compressed striations on the dorsal side. Additionally, many grains identified as *T.* cf. *monococcum* possibly represent two-grained varieties; these were comparable with the macrofossils from single-grained varieties, albeit with a more flattened ventrum, and a prominent ventral compression below the apex. In some cases, grains displayed morphological characteristics that overlapped between two-grained *T. monococcum* and *T. dicoccum,* generally slightly wider and with a more rounded appearance, thus have been recorded as *T. monococcum/dicoccum*.

Glume bases –
Number measured: 10. A: 0.65 (0.51-0.82). B: 0.24 (0.1-0.35). C: 1.12 (0.94-1.44). D: 0.62 (0.5-0.71).

17 spikelet forks, possibly attributable to *T. monococcum* were recovered, intact although displaying some signs of erosion to the surface. In these examples, the rachis is broad in relation to width of the spikelet, with glumes inserted obliquely into the rachis at a level close to the disarticulation scar. The disarticulation scar is shallow and wide and the angle between the glumes is below 90 degrees. Glumes become narrow towards the base in side view, often with a prominent primary keel.

FIGURE 61. TWO EXAMPLES OF T. MONOCOCCUM FROM THE GALERIE DES POTS. THESE ARE RELATIVELY WELL-PRESERVED.

FIGURE 62. TWO RELATIVELY POORLY PRESERVED EXAMPLES OF T. MONOCOCCUM FROM L2B.

Triticum dicoccon (Schrank).
Vernacular name – domestic emmer wheat

Caryopses –
Number measured: 130. L: 5.5 (4.12-6.87). B: 2.9 (1.99-3.86). H: 2.47 (1.73-31).

647 examples and 439 possible examples of *T. dicoccum* were recovered from across 15 contexts at a rate of 0.9% and 13.7% fragmentation respectively. Preservation conditions were varied, from limited signs of erosion, to poorly preserved, fragmented and eroded, thus identifiable only as *T.* cf. *dicoccum*. Caryopses were slender ovate in outline with slightly curving sides to a point or blunted point at the embryo end, and to a bluntly rounded or rounded point at the apex end. A characteristic dorsal hump

was noted in all examples in side view, with the highest point just after the embryo cavity or towards the centre. The ventral side is flattened or concave, or occasionally slightly convex in *T.* cf. *dicoccum* examples distorted by charring, with a deep and narrow ventral furrow. Grains were evenly rounded in transversal section and the surface is smooth and matte, occasionally with impressions of the glumes as compressed striations on the dorsal side. It was also noted that many grains displayed overlapping characteristics between *T. dicoccum* and *T. aestivum/durum/turdigum*, appearing shorter and more rounded in outline than most examples of *T. dicoccum* although slenderer and with a flatter ventrum than *T. aestivum/durum/turdigum*. In these cases, grains were identified as *T. dicoccum/aestivum/durum/turdigum*, and may represent free-threshing wheats, or examples of *T. dicoccum* rounded by the charring process, or cultivars with shorter grains.

Glume bases –
Number measured: 4. A: 0.45 (0.34-0.59). B: 0.24 (0.18-0.29). C: 1.7 (1.6-1.87). D: 0.77 (0.68-0.92).

6 spikelet forks, possibly attributable to *T. dicoccum* were recovered, mostly intact although some with fragmented glumes, with moderate surface erosion. The rachis is narrow in relation to the width of the spikelet in these examples, with glumes inserted obliquely into the rachis at a level below the disarticulation scar. The disarticulation scar is narrow and subcircular, while the angle between the glumes is around or above 90 degrees. In side view, the glumes remain broad towards the base with veining presenting as vertical striations.

FIGURE 63. TWO EXAMPLES OF T. DICOCCUM FROM THE GALERIE DES POTS. THESE ARE RELATIVELY WELL PRESERVED.

FIGURE 64. TWO RELATIVELY POORLY PRESERVED EXAMPLES OF T. DICOCCUM FROM L2B.

Triticum aestivum L./durum Desf./turdigum L.
Vernacular name – naked/free-threshing wheat

Number measured (of *T.* cf. *nudum*): 17. L: 4.73 (4.27-5.35). B: 3.18 (2.86-3.89). D: 2.65 (2.19-3.16).

Very few grains of *T. aestivum/durum.turdigum* or '*T. nudum*' were recovered. Their identification was limited to 3 caryopses identified in earlier analyses by Baudais-Lundstrom and removed for radiocarbon dating (Daumas & Laudet, 2012), and 36 possible examples identified during this analysis across 7 contexts, with no fragmented examples. Their identification was particularly difficult due to the abundance of rounded, shorter grains of *T.* cf. *dicoccum*; 67 grains were recorded as *T. aestivum/durum/turdigum* due to overlapping morphological characteristics. Grains identified as *T.* cf. *aestivum/durum.turdigum* were mostly well-preserved with some surface erosion. These were broad ovate to elliptical in outline with blunted or bluntly rounded embryo and apex ends with a wide and deep ventral furrow. The embryo lies within an ovate cavity. In side view, the dorsal is rounded with the highest point just after the embryo cavity or towards the centre, with a slightly convex ventral side. Grains are mostly symmetrical in transversal section with a rounded off dorsal ridge. The surface is smooth with no glume impressions.

Fabaceae

Pisum sativum L.
Vernacular name – pea

Number measured: 193. Diameter: 3.72 (2.67-5.21)

329 examples and 20 possible examples were recovered, with a rate of 31.3% and 80% fragmentation respectively across 14 contexts. Preservation was variable, but generally good in which the testa and hilum were preserved in many cases, although often fragmented in half, separating the cotyledons, lengthwise from the hilum along the dorsal seam. The seeds were spherical or subspherical in outline with a smooth, matte surface. The hilum is ovate to elliptic with a distinct linear hilar groove, and in an apical position, often with prominent radicle.

FIGURE 65. FIVE COMPLETE EXAMPLES OF PISUM SATIVUM FROM J4B.

Lens culinaris Medik.
Vernacular name – lentil

Number measured: 66. Diameter: 3.27 (2.09-4.04). Height: 1.92 (1.18-2.41)

71 examples and 5 possible examples were recovered, with a rate of 5.6% and 80% fragmentation respectively across 7 contexts. These were well preserved, although also occasionally fragmented lengthwise from the hilum along the dorsal seam. The seeds were a characteristic lens shape taking a compressed circular form, with a smooth, matte surface. The hilum is linear elliptic and in an apical position; the radicle is often slightly protruding.

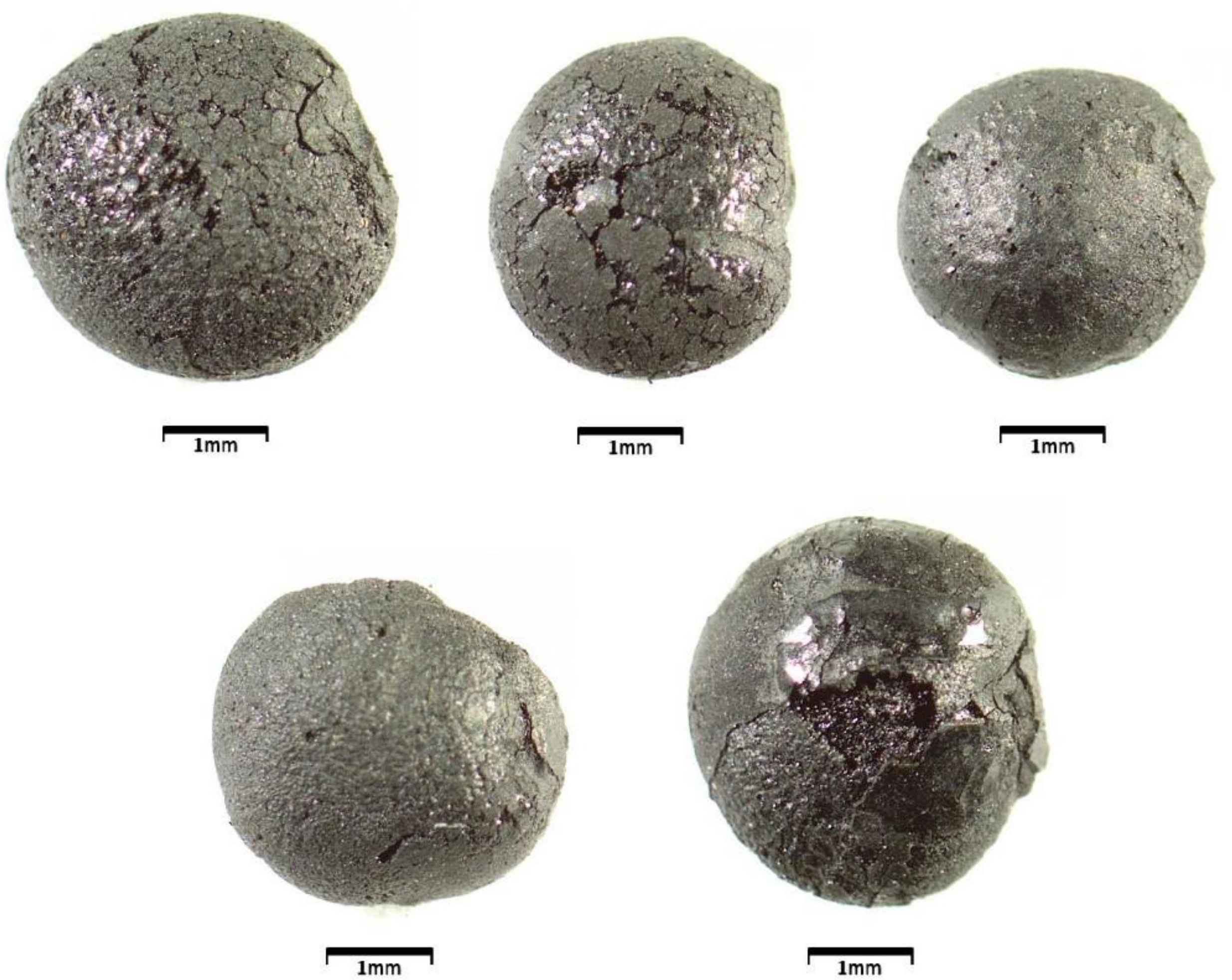


FIGURE 66. FIVE COMPLETE EXAMPLES OF LENS CULINARIS FROM J4B.

A7.2. Arable weeds and ruderal taxa

Poaceae

Poaceae Barnh.
Vernacular name – grasses

Number measured: 12. L: 5.48 (4.7-6.56). B: 1.95 (1.76-2.26). D: 1.72 (1.39-2.26).

20 seeds were identified only as *Poaceae* sp. at a rate of 20% fragmentation across 2 contexts, and generally in a degraded state of preservation. Bearing similarities to many genera within *Poaceae*, these were mostly small caryopses ranging from elongated ovate to oblong, often slender, with a ventral furrow characteristic of *Poaceae*. Apex ends range from rounded to blunted, and embryo ends mostly pointed. In transversal section, caryopses were symmetrical, either evenly rounded, or flattened. These seeds possibly represent common large-seeded grasses of pastoral and arable land, or possibly some smaller and atypically formed cereals. One seed in degraded condition was also identified only as *Poaceae/Lamiaceae*, ovate in outline with a rounded apex and tapering to a point at the embryo end, without a ventral compression being observed.

Bromus L.

Vernacular name: Brome grass

Number measured: 8. L: 5.22 (5.19-5.86). B: 1.7 (1.62-1.78). H: 0.92 (0.75-1.18).

13 examples were recovered from across 2 contexts at a rate of 46.2% fragmentation. Preservation varies from eroded and fragmented to well preserved with little degradation. Caryopses are slender oblong with parallel sides, bluntly rounded at the apex end and pointed at the embryo end. The grain is compressed in transverse section. The ventral face is slightly concave, the dorsal face is convex, and the ventral furrow is shallow. The scutellum is oval, and the embryo does not lie within a cavity. *Bromus* is widespread across the temperate world, often a weed of cereal crops (Tison & Foucault, 2014).

Amaranthaceae

Chenopodium album L.

Vernacular name: Fat hen

Number measured: 1. D: 1.15.

One intact possible example was recovered with little signs of erosion, although without the pericarp attached. The seed is flattened, lenticular in outline and characteristically notched on the margin, and rounded elliptic in transversal section. The seed coat is slightly glossy and smooth. Chenopodium album is a common weed of cereals, but is widespread in various habitats, mostly disturbed land and pasture, up to 1200m in France (Tison & de Foucault, 2014). Historically in prehistoric Europe, *C. album* has been gathered as a food source, mostly for consumption of the leaves, and in rare cases was possibly cultivated as a pseudo-cereal, however it is mostly represented as a prolific weed (Stokes & Rowley-Conwy, 2002).

Brassicaceae

Brassicaceae Burnett. Descurania Webb & Gerthel./Cardamine L.

Vernacular name: Tansymustard/bittercress

Number measured: 1. H: 1.44. B: 0.8.

One degraded but intact example was recovered. The seed is oblong-oval in outline with a rounded apex end and blunted at the base towards a broad notch, and compressed in transversal section, consistent with the forms of *Descurainia* and *Cardamine*. A wide and shallow compression runs along the ventral face, ending short of the apex. The seed coat is mostly eroded, although some very fine longitudinal reticulated cell patterning remains. Two species of *Descurainia* are found today in the Alpine landscape - *D. sophia* and *D. tanacetifolia* - both of which can be found up to 2300m, mostly on alkaline, disturbed soils (Tison & de Foucault, 2014). Numerous varieties of *Cardamine* can be found in wide ranging habitats from damp meadow to woodlands, although generally also prefer alkaline soils (Tison & de Foucault, 2014). This seed is most likely indicative of a weed of disturbed ground.

Fabaceae

Fabaceae Lindl.

Vernacular name: Legumes

Four examples of *Fabaceae* were represented by fragments. The testa was degraded and hilum was indistinguishable, while the forms were consistent with seeds with a compressed spherical outline. These may represent degraded examples of legume crops such as *Pisum* sp. or wild legumes such as *Vicia* sp.

Polygonaceae

Polygonaceae Juss./Cyperaceae Juss.

Vernacular name: knotweed/sedge

One fragment was recovered representing the apex end of one seed, trigonous in transversal section with an acute-pointed apex. The edges are rounded, and surface patterning smooth and matte.

Rumex L.

Vernacular name: Dock/sorrel

Number measured: 1. H: 1.75 (1.3-2.2). D: 1.48 (1.22-1.74).

Two intact examples were recovered across two contexts. Both achenes were trigonous and ovate in outline, with an acutely pointed apex and base. Both examples were rounded-triangular, mostly consistent with, although somewhat larger than *R. acetosella*, while surface patterning was smooth with shiny, rounded edges. Their poor preservation prevents identification to species level, while it is plausible the seeds became rounded during the charring process. Therefore, although the archaeological specimens appear more rounded than the modern uncharred reference examples, Alongside *R. acestosella*, possible candidates may include *R. acestosa*, *R. crispus*, *R. conglomeratus* and *R. sanguineus*.

Rumex acetosella L.

Vernacular name: Sheep's sorrel

Number measured: 1. H: 1.83. D: 1.5.

One possible example was recovered with limited signs of degradation. The achene is rounded trigonous with characteristic rounded, shiny ridges, with a smooth surface overall. The outline is elliptic but rather squat, in which the apex and base ends taper acutely to a point, with a circular basal attachment scar. Although most consistent with *R. acetosella*, this may be surprising as this taxon is uncommon on calcareous soils; although it is historically present in the Diois, it is rare (Breistroffer, 1963). Therefore, this example is identified as *R.* cf. *acetosella*, as other species of Rumex cannot be ruled out completely.

Ranunculaceae

Ranunculus L.

Vernacular name: Buttercup

Number measured: 1. D: 1.5.

One extremely poorly preserved possible charred example of a *Ranunculus* sp. achene was recovered. The surface patterning of the endocarp is degraded, however the lenticular-ovate outline with small beak towards the base, and compressed cross-section is comparable with *Ranunculus* sp.

Rosaceae

Rubus L. (ideaus L/fruticosus agg.)

Vernacular name: Bramble

Number measured: 1. L: 1.3. B: 1.22.

2 seeds were recovered from across 2 contexts at a rate of 50% fragmentation. The intact example is roughly semi-globular in outline. In both examples the raphe is pronounced along the margins with a slightly convex ventral edge and rounded back ridge. The endocarp surface is reticulated with irregular sub-rectangular reticulations. The most likely candidates are *R. idaeus* or *R. fruticosus aggr.* Both species are common in the Alps, in which *R. idaeus* grows up to 2200m, and *R. fruticosus* up to 1700m, along hedgerows, forest edges and undergrowth of disturbed ground (Tison & de Foucault, 2014).

Rubiaceae

Galium L.

Vernacular name: Bedstraw

Number measured: 1. H: 1.09. D: 1.49.

One intact example was recovered, although surface patterning appears eroded. The seed is globose and hollow-centred from the ventral side. The surface patterning is smooth on the dorsal side, and slightly rugulose towards the ventrum. Many species of *Galium* are common on waste ground or cultivated land and hedgerows at a wide range of altitudes, indicative of disturbed lands (Tison & de Foucault, 2014).

A7.3. Wild flora

Cupressaceae

Juniperus L., possible.

Vernacular name: Juniper

One degraded and fragmented macrofossil was recovered. Although recorded as indeterminate, a tentative identification as a possible Juniperus cone could be suggested. The specimen is ovoid, although post-depositionally truncated before the apex, displaying possible scale pads and what is perhaps a short, straight peduncle at the base. *J. communis* is most commonly represented in mountainous regions of France up to 2200m in semi-arid plains (Tison & de Foucault, 2014).

Pinaceae

Abies Mill.

Vernacular name: Fir

13 *Abies* sp. needles were identified across two contexts, in which every ten fragments were counted as one needle. All examples were highly fragmented in which fragments rarely exceeded 5mm in length. Flat needle leaves were identified with a slightly bifurcate apex in most examples. Two shallow linear furrows are present on one side of the leaves giving the appearance of a small linear ridge along the centre of the needle, ending at the apex. These needles are possibly attributable to *Abies alba*, as the most numerous variety in the southern French Alps today (Tison & Foucault, 2014).

Fagaceae

Quercus L.

Vernacular name: Oak

One leaf bud, possibly attributable to *Quercus* was recovered. It is ovoid in outline drawing to a point at the tip. Multiple leaf scales are arranged overlapping each other. Presently, *Q. ilex* and *Q. pubescens* are most abundant in the Diois, while *Q. pubescens* was detected in the anthracological material at Trou Arnaud, thus is a possible candidate (Breistroffer, 1963; Daumas & Laudet, 2012). Both *Q. ilex* and *Q. pubescens* are common on calcareous soils up to 1200m and 1800m respectively (Tison & de Foucault, 2014).

Oleaceae

Fraxinus excelsior L.

Vernacular name: European ash

One extremely small fragment of a possible *Fraxinus excelsior* key was recovered, approximately 1.6mm in length. The fragment is flattened and slightly twisted, with finely longitudinal striate surface patterning, consistent with the wing of *F. excelsior* samara. This species is common in riparian areas up to 1900m in France today, particularly in deciduous forest on cooler soils (Tison & de Foucault, 2014).

Bibliography

Affolter, J. 2011. Les matières premières siliceuses du site du Petit-Chasseur à Sion (Valais). In: M. Besse & M. Piguet, eds. Le site préhistorique du Petit-Chasseur (Sion, Valais): Tome 10, Un hameau du Néolithique moyen. Cahiers d'Archéologie Romande, 124 (Archaeologia Vallesiana, 6). Lausanne: Cahiers d'Archéologie Romande. pp 157–165.

AHDB, 2018. Barley growth guide. Kenilworth: AHDB Cereals and Oilseeds.

Akeret, Ö., 2005. Plant remains from Bell Beaker site in Switzerland, and the beginnings of Triticum spelta (spelt) cultivation in Europe. Vegetation History and Archaeobotany. 14, pp. 279-286.

Akeret, Ö. & Geith-Chauvière, I., 2003. Les macrorestes végétaux. In: S. Wüthrich, ed. Saint Aubin/Derrière la Croix. Un complexe mégalithique durant le Néolithique moyen et final. Archéologie Neuchâtéloise. 29, pp. 281-293.

Akeret, Ö., et al., 1999. Plant macrofossils and pollen in goat/sheep faeces from the Neolithic lake-shore settlement Arbon Bleiche 3, Switzerland. The Holocene. 9(2), pp. 175-182. doi.org/10.1191/095968399666631581

Alexander, J., 1977. The 'frontier' concept in prehistory: the end of the moving frontier. In: J. V. S. Megaw, ed. Hunters, Gatherers, and First Farmers Beyond Europe. Surrey: Leicester University Press, pp. 25-40.

Alexander, J., 1978. Frontier studies and the earliest farmers in Europe. In: D. Green, C. Haselgrove & M. Spriggs, eds. Social Organisation and Settlement: Contributions from Anthropology, Archaeology and Geography, Part 1. Oxford: BAR International Series (Supplementary) 47 (1), pp. 13-30.

Allix, A., 1929. Un pays de haute montagne: L'Oisans; étude géographique. Paris: Armand Colin.

Alonso, N. et al., 2013. The effect of dehusking on cereals: experimentation for archaeobotanical comparison. In: P. C. Anderson, C. Cheval, A. Durand., eds. Regards croisés sur les outils liés au travail des végétaux: actes des rencontres 23-25 octobre 2012: XXXIII rencontres Internationales d'Archéologie et d'Histoire d'Antibes. An interdisciplinary focus on plant-working tools. Antibes: Editions APDCA. pp 155-168.

Angelucci, D. E., 2009. Shepherds and karst: The use of caves and rock-shelters in the Mediterranean region during the Neolithic. World Archaeology. 41(5), pp. 191-214. doi.org/10.1080/00438240902843659

Antolin, F. & Buxo, R., 2011. Proposal for the systematic description and taphonomic study of carbonized cereal grain assemblages: a case study of an early Neolithic funerary context in the cave of Can Sadurni (Begues, Barcelona province, Spain). Vegetation History and Archaeobotany. 20, pp. 53-66, doi.org/10.1007/s00334-010-0255-1.

Antolín, F. et al., 2018. Herders in the mountains and farmers in the plains? A comparative evaluation of the archaeobiological record from Neolithic sites in the eastern Iberian Pyrenees and the southern lower lands. Quaternary International. 484, pp. 75-93. doi.org/10.1016/j.quaint.2017.05.056

Antolín, F. et al., 2020. A new look at late Neolithic plant economy from the site of Zürich-Parkhaus Opéra (Switzerland): methods, activity areas and diet. In: A. Hafner et al. eds. Settling Waterscapes in Europe. The Archaeology of Neolithic and Bronze Age Pile-Dwellings. Open Series in Prehistoric Archaeology 1. Bern and Heidelberg: Propylaeum. pp. 157–172. doi.org/10.11588/propylaeum.714

Argant, J. & Argant, A., 2000. Mise en evidence de l'occupation ancienne d'un site d'altitude analyse pollinique du lac du Lauzon (Drôme). Geologie Alpine. 31, pp. 61-71.

Argant, J., Heinz, C. & Brochier, J. L., 1991. Pollens, charbons de bois et sédiments : l'action humaine et la végétation, le cas de la grotte d'Antonnaire (Montmaur-en-Diois, Drôme). Archeosciences, revue d'archéométrie, 15, pp. 29-40.

Argant, J., Damuas, J. C. & Laudet, R., 1996. Apport de l'analyse pollinique à la compréhension d'une structure énigmatique au Trou Arnaud (Saint-Nazaire-le-Desert, Drôme). Revue d'Archéométrie. Supplement: Colloque d'Archéométrie. Périgueux, 26-29 avr. 1995. pp. 177-180.

Argant, J., Lopez-Saez, J. A. & Bintz, P., 2006. Exploring the ancient occupation of a high altitude site (Lake Lauzon, France): Comparison between pollen and non-pollen palynomorphs. Review of Palaeobotany and Palynology. 141(1-2), pp. 151-163. doi.org/10.1016/j.revpalbo.2006.01.010

Arobba, D., Biagi, P., Formicola, V., Isetti, E. & Nisbet, R., 1987. Nuevo osservazioni sull'Arma Dell'Aquila (Finale Ligure - Savona). In: Il Neolitico in Italia, Firenze, 7-10 novembre 1985, Volume I. Firenze: Istituto italiano di Preistoria e Protostoria. pp. 541-551.

Baioni, M. et al., 2005. L'Isolino di Varese. Alcuni dati da recenti interventi. In: Ph. Della Casa & M. Trachsel, eds. WES'04 – Wetland Economies and Societies. Proceedings of the International Conference in Zurich, 10-13 March 2004. Collectio Archaeologica 3. Zurich: Chronos, pp. 209–214.

Bajard, M. et al., 2020. Pastoralism increased vulnerability of a subalpine catchment to flood hazard through changing soil properties. Palaeogeography, Palaeoclimatology, Palaeoecology. 538, pp. 109462.

Balkcom, K. et al., 2007. Managing cover crops in conservation tillage systems. In: Clark, E., ed. Managing Cover Crops Profitably, Sustainable Agriculture Research and Education (SARE) Handbook Series Book 9. College Park, Maryland: SARE. pp. 44-62

Banks, W. E., Antunes, N., Riguad, S. & d'Errico, F., 2013. Ecological constraints on the first prehistoric farmers in Europe. Journal of Archaeological Science, 40(6), pp. 2746-2753.

Barfield, L. H., Borello, M. A., Buteux, S. & Ciaraldi, M., 2002. Scavi preistorici sulla Rocca di Manerba, Brescia. In: A. Ferrari & P. Visentini, eds. Il declino del mondo neolitico. Ricerche in Italia centro-settentrionale fra aspetti peninsulari, occidentali e nord-alpini, Pordenone: Quaderni del Museo Archeologico del Friuli Occidentale, 4, 2001. Pordenone: Museo delle Scienze. pp. 291-309.

Basso, E. et al., 2006. The Neolithic pottery of Abri Pendimoun (Castellar, France): A petro-archaeometric study. Geological Society London Special Publications. 257(1), pp. 33-48. doi.org/ 10.1144/GSL.SP.2006.257.01.03

Battentier, J., 2016. La grotte de Pertus II (Méailles, Alpes-de-Haute-Provence): exploitation du couvert forestier au chasséen récent (3850-3650 cal. BC). In: E. Cauliez, et al., eds. Actes des 11eme rencontres Méridionales de Préhistoire Récente, De la tombe au territoire – Actualité de la Recherche. Toulouse: Archives d'écologie préhistorique. pp.223-232.

Baudais, D., 1995. Le camp néolithique de Savièse, La Soie. In: A. Gallay, ed. Dans les Alpes, à l'aube du métal. Archéologie et bande dessinée, Sion: Musées cantonaux du Valais. pp. 91-96.

Baum, T. et al., 2019. 'How many how far? Quantitative models of Neolithic land use for six wetland sites on the northern Alpine forelands between 4300 and 3700 BC. Vegetation History and Archaeobotany, [Online].

BBC News., 2020. Storm Alex: Floods and landslides hit France and Italy. BBC News. Date accessed: 27/11/2020. Accessible at: https://www.bbc.co.uk/news/world-europe-54402096

Beeching, A., 1981. Introduction a l'etude des stades neolithiques et chalcolithiques dans le Bassin du Rhône moyen. Lyon: Universite Lyon.

Beeching, A., 2002. La fin du Chasseen et le Neolithique final dans le bassin du Rhône moyen. In: A. Ferrari & P. Visentini, eds. Il declino del mondo neolitico. Icherche in Italia centro-settentrionale fra aspetti peninsulari, occidentali e nord-alpini Atti dek convergno de Pordemone Quaderni del Museo Archeologico del Friuli Occidentale 4. Pordenone: Museo delle Scienze, pp. 67-83.

Beeching, A., 2003. Mobilite et societes neolithiques dans les Alpes occidentales et la France meridionale. Preistorica alpin, 39, pp. 175-187.

Beeching, A. et al., 2000. Chasseens: agriculteurs ou éleveurs, sédentaires ou nomades? Quels types de milieux, d'economies et de societies?. In: M. Laduc, N. Valdeyron & J. Vaquer, eds. Sociétés et espaces, Rencontres méridionales de Préhistoire récente. Toulouse: Archives d'ecologie préhistorique, pp. 59-79.

Beeching, A., Brochier, J. L. & Argant, C., 2004. Première anthropisation et néolithisation: contextes environnemental et humain dans le bassin du Rhône et les Alpes. In: H. Richard, ed. Néolithisation précoce: premières traces d'anthropisation du couvert végétal à partir des données polliniques. Besançon: Presses Universitaires Franc-comtoises, pp. 147-162.

Beeching, A. et al., 2005. Espaces physiques et territoires du Néolithique moyen en vallée du Rhône. In: Berger, J. F. et al., eds. Temps et espaces de l'homme en société, analyses et modèles spatiaux Recontres internationals d'archéologie et d'histoire d'Antibes, Juan-les-Pins, Éditions APDCA. pp. 463-468

Bencze, S. et al., 2020. Re-Introduction of Ancient Wheat Cultivars into Organic Agriculture—Emmer and Einkorn Cultivation Experiences under Marginal Conditions. Sustainability. 12, 1584. doi:10.3390/su12041584

Berger, J. F., 2003. Les étapes de la morphogenèse holocène dans le sud de la France. In: S. Van der Leeuw, F. Favory & J. L. Fiches, eds. Archéologie et systèmes socio-environnementaux. Études multiscalaires sur la vallée du Rhône dans le programme Archaeomedes. Collection CRA-Monographies, 27. Paris: CNRS Editions, pp. 87-167.

Berger, J. F., 2005. Sédiments, dynamique du peuplement et climat au Néolithique ancien. In: J. Guilaine, ed. Populations néolithiques et environnements - Séminaire du Collège de France. Paris: Errance, pp. 155-212.

Berger, J. F. et al., 2019. Holocene land cover and population dynamics in southern France. The Holocene, 29(5), pp. 776-798.

Biagi, P., Cremaschi, M. & Nisbet, R., 1993. Soil exploitation and early agriculture in northern Italy. The Holocene. 3, pp. 164-168.

Biagi, P. & Nisbet, R., 1986. Popolazione e territorio in Liguria tra il XII e il IV millenio b.c. In: R. La Guadria, ed. Scritti in ricordo di Graziella Massari Gaballo e di Umberto Tochetti Pollini. Milano: Edizioni ET. pp. 19-27.

Biagi, P. & Nisbet, R., 1987. Ursprung der Landwirtschaft in Norditalien. Zeitschrift für Archäologie. 21, pp. 11-24.

Billamboz, A., Dieckmann, B., Maier, U. & Vogt, R., 1992. Exploitation du sol et de la forêt à Hornstaad-Hörnle I (RFA, Bodensee). In: Archéologie et environnement des milieux aquatiques : lacs, fleuves et tourbières du domaine alpin et de sa périphérie, Actes du 116è Congrès National des Sociétés Savantes, Chambéry-Annecy, 1991. éditions du C.T.H.S. Villeneuve d'Ascq Cedex: Association Française des Presses d'Université - Diffusion (AFPU-D). pp. 119-148.

Binder, D., et al., 1993. L'abri Pendimoun à Castellar (Alpes Maritimes): nouvelles données sur le complexe culturel de la céramique imprimée méditerranéenne dans son contexte stratigraphique. Gallia Préhistoire. 35, pp. 177-251.

Blaise, E. et al., 2010. L'élevage du Néolithique moyen au Néolithique final dans le Midi méditerranéen de la France: état des donnéesarchéozoologiques. In: O. Lemercier, R. Furestier, E. Blaise, eds. Quatrième millénaire. La transition du Néolithique moyenau Néolithique final dans le sud-est de la France et les régions voisines (Monographies d'Archéologie Méditerranéenne, 27). Lattes: Publications de l'UMR 5140. pp. 261-284

Blanchard, R., 1918. Le contraste climatique entre Vercors et Diois. Revue de Geographie Alpine, 6(4), pp. 427-446.

Boardman S. & Jones G. 1990. Experiments on the effects of charring on cereal plant components. Journal of Archaeological Science. 17, pp. 1-11.

Bocquet-Appel, J. P., Naji, S., Linden, M. V. & Kozlowski, J. K., 2009. Detection of diffusion and contact zones of early farming in Europe from the space-time distribution of 14C dates. Journal of Archaeological Science, 36(3), pp. 807-820.

Bogaard, A., 2004. Neolithic Farming in Central Europe: An Archaeobotanical Study of Crop Husbadry Practices. Hove: Psychology Press.

Bogaard, A. et al., 2016. Combining functional weed ecology and crop stable isotope ratios to identify cultivation intensity: a comparison of cereal production regimes in Haute Provence, France and Asturias, Spain. Vegetation History and Archaeobotany, 25(1), pp. 57-73.

Bollinger, T., 1994a. Samenanalytische Untersuchung der früh-jungsteinzeitlichen Seeufersiedlung Egolzwil 3, Dissertationes Botanicae 221. Berlin-Stuttgart: J. Cramer.

Bollinger, T., 1994b. Wirtschaft und Umwelt des jungsteinzeitlichen Wohnplatzes Egolzwil 3. Heimatkunde des Wiggertals. 52, pp. 137-224.

Borello, M. & Willigen, S., 2013. Identités céramiques et groupes néolithiques dans les Alpes occidentales. In: Borello, M. Les hommes préhistoriques et les Alpes, BAR International Series 2476. Geneva: Département de géographie et environnement de l'Université de Genève. pp. 59-68.

Bouby, L., Fages, G. & Treffont, J. M., 2005. Food storage in two Late Bronze Age caves of Southern France: palaeoethnobotanical and social implications. Vegetation History and Archaeobotany. 14(4), pp. 313-328.

Bouby, L. et al., 2019. Early farming economy in Mediterranean France: fruit and seed remains from the Early to Late Neolithic levels of the site of Taï (ca 5300–3500 cal BC). Vegetation History and Archaeobotany. 28, pp. 17-34.

Bouby, L. et al., 2020a. Early Neolithic (ca. 5850-4500 cal BC) agricultural diffusion in the Western Mediterranean: An update of archaeobotanical data in SW France. PLoS ONE, 15(4).

Bouby, L., Marinval, P. & Nuria, R., 2020b. Late Neolithic plant subsistence and farming activities on the southern margins of the Massif Central (France). The Holocene, 30(5), pp. 599-617.

Bourgarit, D. et al., 2008. The beginning of copper mass production in the western Alps: the Saint-Veran mining area considered. Historical Metallurgy, 42(1), pp. 1-11.

Brandolini, A., Volante, A. & Heun, M., 2016. Geographic differentiation of domesticated einkorn wheat and possible Neolithic migration routes. Heredity. 117, pp. 135-141.

Bravard, J. P., et al., 2003. Mouvements de masse et paleoenvironment quaternaire: les paleo-lacs de Boulc (Haut-Diois, Alpes, France). Revue de Géographie Alpine, 91(1), pp. 9-27.

Bréhard, S., 2011. Le complexe chasséen vu par l'archéozoologie: révision de la dichotomie Nord-Sud et confirmation de la partition fonctionnelle au sein des sites méridionaux. Bulletin de la Société préhistorique française, 108(1), pp. 73-92.

Bréhard, S., Beeching, A. & Vigne, J. D., 2010. Shepherds, cowherds and site function on middle Neolithic sites of the Rhône valley: An archaeozoological approach to the organization of territories and societies. Journak of Anthropological Archaeology, 29(2), pp. 179-188.

Breistroffer, M., 1963. Flore abrégée du Diois (Drôme). Bulletin de la Société Botanique de France. 110(2:89e 89e Session Extraordinaire à Die et à Grenoble), pp. 42-143.

Briggs D. E., 1978. Barley. New York: Wiley.

Brochier, J. L., 1997. Contexte morphodynamique et habitat humain de la moyenne vallée du Rhône au cours de la Préhistoire récente. In: J. P. Bravard & M. Presteau, eds. Dynamique du Paysage: Entretiens de geoarchaeologie (Table ronde tenue a Lyon les 17 et 18 novembre 1995). Lyon: Alpara, pp. 87-102.

Brochier, J. L., Beeching, A., Maamar, H. S. & Vital, J., 1999. Les grottes bergeries et la pastoralisme alpin durant la fin de la préhistoire. In: A. Beeching, ed. Circulations et identités culturelles alpin a la fin de la préhistoire - Matériaux pour une études - Programme CIRCALP 1997-1998. Valence: Centre d'Archéologie de Valence, pp. 77-114.

Brochier, J. L., Mandier, P., Argant, J. & Petiot, P., 1991. Le cône détritique de la Drôme: une contribution à la connaissance de l'Holocène du Sud-Est de la France. Quaternaire, 2(2), pp. 83-99.

Brombacher, C., 1997. Archaeobotanical investigations of Late Neolithic lakeshore settlements (Lake Biel, Switzerland). Vegetation History and Archaeobotany. 6, pp. 167-186.

Brombacher, C., 2000. Archäobotanische Untersuchungen. In: A. Hafner & P. J. Suter, eds. -3400. Die Entwicklung der Bauerngesellschaften im 4. Jahrtausend v.Chr. am Bielersee aufgrund der Rettungsgrabungen von Nidau und Sutz-Lattrigen. Bern: Berner Lehrmittel- und Medienverlag. pp. 156-168.

Brombacher, C. & Jacomet, S., 1997. Ackerbau, Sammelwirtschaft und Umwelt: Ergebnisse archäobotanischer Untersuchungen. In: J. Schibier, H. Hüster-Plogmann, S. Jacomet, C. Brombacher, E. Gross-Klee, & A. Rast-Eicher, Eds. Ökonomie und Ökologie neolithischer und bronzezeitlicher Ufersiedlungen am Zürich see. Monographien der Kantonsarchäologie Zürich 20. Zürich: Direktion der Öffentlichen Bauten des Kantons Zürich. pp. 220-299.

Brombacher, C. & Dick, M., 1987. Die Untersuchung der botanischen Makroreste. In: E. Gross, et al., eds. Zürich "Mozartstrasse". Neolithische und bronzezeitliche Ufersiedlungen, Band 1, Monographien der Kantonsarchäologie Zürich 4. Zürich: Orell Füssli Verlag. pp. 198-211.

Brombacher, C. & Jacomet, S., 2003. Ackerbau, sammelwirtschaft und umwelt. In: H. Zwahlen, ed. Die jungneolithische Siedlung Port-Stüdeli. Bern: Paul Haupt Verlag., pp. 66-86.

Brombacher, C. & Vandorpe, P. 2012. Untersuchungen zu Wirtschaft und Umwelt aus der mittelneolithischen Fundstelle von Zizers GR-Friedau. In: A. Boschetti-Maradi et al., eds. Form, Zeit und Raum: Festschrift für Werner E. Stöckli zu seinem 65. Geburtstag. Antiqua 50. Basel:Basel Archäologie Schweiz. pp. 95-104.

Brown, T. A. et al., 2015. Recent advances in ancient DNA research and their implications for archaeobotany. Vegetation History and Archaeobotany. 24(1), pp. 207-214.

Cadeddu, F. et al., 2021. Ancient wheat species are suitable to grain-only and grain plus herbage utilisations in marginal Mediterranean environments. Agronomy for Sustainable Development. 41, 15. doi.org/10.1007/s13593-021-00670-7

Cappers, R.T. J. & Bekker, R. M., 2013. A Manual for the Identification of Plant Seeds and Fruits. Groningen: Barkhuis & University of Groningen Library.

Cappers, R. T. J. & Raemaekers, D. C. M., 2008. Cereal Cultivation at Swifterbant? Neolithic Wetland Farming on the North European Plain., Current Anthropology. 49(3), pp. 385-402.

Carcaillet, C., 1998. A spatially precise study of Holocene fire history, climate and human impact within the Maurienne valley, North French Alps. Journal of Ecology. 86(3), pp. 384-396. doi.org/10.1046/j.1365-2745.1998.00267.x.

Carrer, F., 2015. Herding strategies, dairy economy, and seasonal sites in the southern Alps: ethnoarchaeological inferences and archaeological implications. Journal of Mediterranean Archaeology, 28(1), pp. 3-22.

Carrer, F., 2020. Archaeology of the Alps, in: Encyclopedia of Global Archaeology. Springer International Publishing, Cham, pp. 1–12. doi.org/10.1007/978-3-319-51726-1_3492-1

Castelletti, L., 1975. Resti vegetali macroscopici di Campo Ceresole-Vhò di Piadena (neolitico inferiore). Preistoria Alpina. 11, pp. 125-126.

Castelletti, L. & Motella de Carlo, S., 1998. L'uomo e le piante nella Preistoria. L'analisi dei resti macroscopici vegetali. In: L. Mercando & E. M. Venturino Gambari, eds. Archeologia in Piemonte. Volume I: la Preistoria, Soprintendenza Archeologica del Piemonte. Torino: U. Allemandi. pp. 57-73.

Champion, L. & Fuller, D. Q., 2019. Archaeobotany: Methods. In: T. Spear, ed. The Oxford Encyclopedia of African Historiography: Methods and Sources. Oxford: Oxford University Press, p. [Online].

Charles, M. et al., 2015. Nor ever lightning char thy grain: establishing archaeologically relevant charring conditions and their effect on glume wheat grain morphology, STAR: Science & Technology of Archaeological Research. 1(1). pp. 1-6. doi.org/10.1179/2054892315Y.0000000008

Climate-data.org, 2021. Sollières-Sardières climate [Online.] Cimate-data.org. Available at: https://en.climate-data.org/europe/france/rhone-alpes/sollieres-sardieres-101478/, Accessed on 23 June 2021.

Cocca, G., Sturaro, E., Gallo, L. & Ramanzin, M., 2012. Is the abandonment of traditional livestock farming systems the main driver of mountain landscape change in Alpine areas?. Land Use Policy, 29(4), pp. 878-886.

Colledge, S., 2016. The Cultural Evolution of Neolithic Europe. EUROEVOL Dataset 3: Archaeobotanical Data. Journal of Open Archaeology, 5(e1).

College, S. & Conolly, J., 2014. Wild plant use in European Neolithic subsistence economies: a formal assessment of preservation bias in archaeobotanical assemblages and the implications for understanding changes in plant diet breadth. Quaternary Science Reviews. 101, pp. 193-206. doi.org/10.1016/j.quascirev.2014.07.013

Communauté des Communes du Diois., 2014. *Plan Pastoral Territorial du Diois 2015-2020.* Communauté des Communes du Diois, Pays Diois aux sources de la Drôme. Available at: https://www.paysdiois.fr/wp-content/uploads/2019/10/candidature_ppt_diois-2015-2020.pdf, Accessed on 27 July 2021.

Contreras, D. A. et al., 2018. Regional paleoclimates and local consequences: Integrating GIS analysis of diachronic settlement patterns and process based agroecosystem modeling of potential agricultural productivity in Provence (France). PLoS One. 13, pp. 1-27. doi.org/10.1371/journal.pone.0207622

Corti, P. et al., 1998. Siti umidi tardoneolitici : nuevo dati da Palu' di Livenza (Friuli-Venezia Giulia, Italia). In: C. Peretto & C. Giunchi, eds., Atti del XIII Congresso, Forli, Union Internazionale delle scienze preistoriche e protostoriche, Volume 6-tome II, 8-14 settembre 1996, ABACO. pp. 1379-1387.

Courtin, J. & Erroux, J., 1974. Aperçu sur l'agriculture préhistorique dans le Sud-Est de la France. Bulletin de la Société Préhistorique Française. 71, pp. 321-334.

Daumas, J. C. & Laudet, R., 1988. La Grotte du Trou Arnaud, Saint-Nazaire-le-Desert (Drôme): 40 ans d'explorations 1948-1988. La Motte-Chalancon: Club Sportif et Culturel Mottois.

Daumas, J. C. & Laudet, R., 1998. Prehistorire au Trou Arnaud, Saint-Nazaire-le-Desert (Drôme), Tome I. La Motte-Chalancon: Club Sportif et Culturel Mottois.

Daumas, J. C. & Laudet, R., 2012. Prehistorire au Trou Arnaud, Saint-Nazaire-le-Desert (Drôme), Tome II, La Motte-Chalancon: Club Sportif et Culturel Mottois.

Degasperi, N., Mottes, E. & Rottoli, M., 2006. Recenti indagini nel sito neolitico de la Vela di Trento. In: A. Pessina & P. Visentini, eds. Preistoria dell'Italia settentrionale. Studi in ricordo di Bernardino Bagolini, Udine, settembre 2005. Udine: Edizioni del Museo Friulano di Storia Naturale. pp. 143-168.

Delhon, C., 2018. Is Choice Acceptable? How the Anthracological Paradigm May Hinder the Consideration of Fuel Gathering as a Cultural Behaviour. Environmental Archaeology; The Journal of Human Palaeoecology.

Delhon, C., Martin, L., Argant, J. & Thiebault, S., 2008. Shepherds and plants in the Alps: multi-proxy archaeobotanical analysis of neolithic dung from La Grande Rivoire (Isere, France). Journal of Archaeological Science, 35(11), pp. 2937-2952.

Delhon, C., Thiebault, S. & Berger, J. F., 2009. Environment and landscape management during the Middle Neolithic in Southern France: Evidence for agro-sylvo-pastoral systems in the Middle Rhône Valley. Quaternary International. 200, pp. 50-65.

Della Cassa, P., 2005. Lithic resources in the early prehistory of the Alps. Archaeometry. 47(2), pp. 221-234. doi.org/ 10.1111/j.1475-4754.2005.00198.x

Demoule, J. P., Dubouloz, J. & Manolakakis, L., 2005. L'emergence des premiers societes complexes (4500-3500). In: J. P. Demoule, ed. La revolution neolithique en France. Paris: La Decouverte, pp. 61-77.

Dobrowolska, D., 2011. A review of European ash (Fraxinus excelsior L.): implications for silviculture. Forestry: An International Journal of Forest Research. 84(2), pp. 133-148. doi.org/10.1093/forestry/cpr001

Dolfini, A., Angelini, I. & Artioli, G., 2020. Copper to Tuscany - Coals to Newcastle? The dynamics of metalwork exchange in early Italy. PLoS ONE, 15(1).

Drobinski, P. et al., 2005. Summer mistral at the exit of the Rhône valley. Quarterly Journal of the Royal Meteorological Journal. 131(605), pp. 353-375. doi.org/10.1256/qj.04.63

Edje, O. 1990. Relevance of the workshop to farming in eastern and southern Africa. In: S. Waddington, A. Palmer, O., Edje, eds. Research methods for cereal/legume intercropping: proceedings of a workshop on research methods for cereal/legume intercropping in eastern and southern Africa, Mexico. (CIMMYT eastern and southern Africa on-farm research network report no. 17). Texcoco: Centro International de Mejoramiento de Maíz y Trigo. pp 12

EEA, 2009. Regional climate change and adaptation: The Alps facing the challenge of changing water resources. European Environment Agency Report Number 8. [Online] Available at https://www.eea.europa.eu/publications/alps-climate-change-and-adaptation-2009. Accessed on 23 June 2021.

Egli, M. & Poulenard, J., 2016. Soils of Mountainous Landscapes. In: D. Richardson et al., eds. The International Encyclopedia of Geography. Oxford: John Wiley & Sons. doi.org/10.1002/9781118786352.wbieg0197

Erskine,W. & El Ashkar, F. 1993. Rainfall and temperature effect on lentil (Lens culinaris) seed yield in Mediterranean environments. The Journal of Agricultural Science. 121(03), pp. 347-354. doi.org/10.1017/S0021859600085543

Escarre, J. & Thompson, J. D., 1991,. The Effects of Successional Habitat Variation and Time of Flowering on Seed Production in Rumex Acetosella. Journal of Ecology. 79(4), pp. 1099-1112. doi.org/10.2307/2261101

Estel, S., Kuemmerle, T. & Levers, C., 2016. Mapping cropland-use intensity across Europe using MODIS NDVI time series. Environmental Research Letters, 11.

Evett, D. & Renfrew, J., 1971. L'agricoltura neolitica italiana: una nota sui cereal. Rivista di scienze preistoriche. XXVI, pp. 403-415.

Fauquette, S. et al., 2018. The Alps: A Geological, Climatic and Human Perspective on Vegetation History and Modern Plant Diversity. In: C. Hoorn, A. Perrigo & A. Antonelli, eds. Mountains, Climate and Biodiversity. Hoboken: John Wiley & Sons, pp. 413-428.

Favre, P., 2002. Archäobotanik. In: C. Haiser-Pult & J. Gisler eds. Die Seeufersiedlungen in Horgen. Die neolithischen und bronzeitlichen Fundstellen Dampfschiffsteg und Scheller, Monographien der Kantonsarchäologie Zürich, 36. Zürich: Zürich and Egg. pp. 150-181.

Festi, D. et al., 2011. The Late Neolithic settlement of Latsch, Vinschgau, northern Italy: Subsistence of a settlement contemporary with the Alpine Iceman, and located in his valley of origin. Vegetation History and Archaeobotany. 20(5), pp. 367-379. doi.org/10.1007/s00334-011-0308-0

Figueiral, I. & Sejalon, P. 2014. Archaeological wells in southern France: Late Neolithic to Roman plant remains from Mas de Vignoles IX (Gard) and their implications for the study of settlement, economy and environment. Environmental Archaeology. 19(1), pp. 23-38. doi.org/10.1179/1749631413Y.0000000009

Fiorentino, G., Muntoni, I. M. & Fontana, A., 2000. La neolitizzazione delle murge baresi: ambienti, insediamenti e attivita produttive. In: A. Pessina & G. Muscio, eds. La Neolitizzazione tra Oriente e Occidente, Atti del Convegno di Studi, Udine 23-24 Aprile 1999. Commune di Udine: Edizione del Museo Friulano di Storia Naturale. pp. 381-412

Fleury, P. et al., 2008. Implementing Sustainable Agriculture and Rural Development in the European Alps. Mountain Research and Development. 28(3), pp. 226-232. doi.org/10.1659/mrd.1002

Follieri, M., 1987. L'agriculture des plus anciennes communautés rurales d'Italie. In: J. Guilaine, J. Courtin, J. L. Roudil & J. L. Vernet, eds. Premières communautés paysannes en Méditerranée occidentale, Montpellier, 26-29 avril 1983. Paris: éditions du CNRS. pp. 243-247.

Fort, J., 2012. Synthesis between demic and cultural diffusion in the Neolithic transition in Europe. PNAS, 109(46), pp. 18669-18673.

Frick, B. & Mackenzie, J. 2016. Intercropping: Increasing Crop Diversity [Online]. Pivot, Prairie Organic Grain Initiative. Available at: https://www.pivotandgrow.com/wp-content/uploads/2019/08/PIVOT_POGI_Factsheet_Intercropping_102816.pdf. Accessed on 3 August 2021

Fuller, D. & Harvey, E. L., 2006. The archaeobotany of Indian pulses: identification, processing and evidence for cultivation. Environmental Archaeology. 11(2), pp. 219-246. doi.org/10.1179/174963106x123232

Fyfe, R. M., Woodbridge, J. & Roberts, N., 2015. From forest to farmland: pollen-inferred land cover change across Europe using the psuedobiomization approach. Global Change Biology. 21, pp. 1197-1212.

Gallay, A., 1990. La place des Alpes dans la neolithisation de l'Europe. In: P. Biagi, ed. The neolithisation of the Alpine region: papers delivered at the international round table. Brescia. Brescia: Museo civico di scienze naturali di Brescia, pp. 23-42.

Garnsey, P., 1988. Famine and food supply in the Graeco-Roman world. New York: Cambridge University Press.

Gernigon, K., 2016. Villages before houses? The neolithisation of Europe reconsidered through the concept of the household. Palethnologie, 8.

Gibaja, J. et al., 2017. The Neolithic reaping knives from Egolzwil 3: A Mediterranean technical tradition in the late 5th millennium Swiss Neolithic. Quaternary International. 427(B), pp. 211-224. doi.org/10.1016/j.quaint.2015.12.075

Gidon, M., 2016. Chainons du Diois et des Baronnies. [Online] Available at: http://www.geolalp.com//diois/index_diois.html [Accessed 1 12 2020].

Giguet-Covex, C. et al., 2011. Changes in erosion patterns during the Holocene in a currently treeless subalpine catchment inferred from lake sediment geochemistry (Lake Anterne, 2063 m a.s.l., NW French Alps): The role of climate and human activites. The Holocene, 21(4), pp. 651-665.

Gilck, F. & Poschlod, P., 2019. The origin of alpine farming: A review of archaeological, linguistic and archaeobotanical studies in the Alps. The Holocene, 29(9), pp. 1503-1511.

Gkiasta, M., Russell, T., Shennan, S. & Steele, J., 2004. Neolithic transition in Europe : The radiocarbon record revisited. Antiquity, 77(295), pp. 45-62.

Grains Research and Development Corporation., 2018. Nitrogen Fixation in Field Pea [Online]. GRDC, Australian Government. Available at: https://grdc.com.au/tt-nitrogen-fixation-in-field-pea. Accessed on 30 July 2021

Green, W. A., 2009. Hatching seeds before they're counted: Graphical methods for interpreting archaeobotanical data. Archaeological and Anthropological Sciences. 1, pp. 1-13.

Guilaine, J., 2001. La diffusion de l'agriculture en Europe: une hypothese arythmique. Zephyrus. 53-54, pp. 267-272.

Guilaine, J. & Manen, C., 2007. From Mesolithic to Early Neolithic in the western Mediterranean. Proceedings of the British Academy. 144, pp. 21-51.

Hafner, A., Brunner, M. & Laabs, J., 2017. Archaeology of the Alpine space. Research on the foothills, valley systems and high mountain landscapes of the Alps. In: P. Shydlovskyi, ed. Human & Landscape: Prehistoric Archaeology of Eastern Europe. Vita Antiqua 9. Kyiv: The Vovk Center for Paleoethnological Research, pp. 16-37.

Hafner, A. & Schwörer, C., 2017. Vertical mobility around the high-alpine Schnidejoch Pass. Indications of Neolithic and Bronze Age pastoralism in the Swiss Alps from paleoecological and archaeological sources. Quaternary International. xxx, pp. 1-16. doi.org/10.1016/j.quaint.2016.12.049

Hanjalova, M. & Dreslerova, D., 2010. Ethnobotany of einkorn and emmer in Romania and Slovakia: Towards interpretation of archaeological evidence. Pamatky Archeologicke. 101, pp. 169-202.

Hauggaard-Neilson, H. et al., 2006. Pea-barley intercrops use nitrogen sources 20-30% more efficiently than the sole crops [Online]. INTERCROP project consortium. Available at: https://orgprints.org/id/eprint/7487/1/INTERCROP_WP3_v2.pdf. Accessed on 29 July 2021

Heiss, A. G., et al. 2017. State of the (t)art: Analytical approaches in the investigation of components and production traits of archaeological bread-like objects, applied to Barley in two finds from the Neolithic lakeshore settlement Parkhaus Opéra (Zürich, Switzerland). PLoS ONE. 12(8), e0182401. doi.org/10.1371/journal.pone.0182401

Hillman, G. C. et al., 1996. Identification of archaeological remains of wheat: the 1992 London workshop. Circaca, The Journal of the Association for Environmental Archaeology. 12(2), pp. 195-209.

Howorth, J. P., 2020. Archaeobotany in the 4th Dimension: Visualising Specialist Data in a 3D GIS. Lund: University of Lund.

Jacomet, S., 1986. Kulturpflanzenfunde aus der neolithischen Seeufersiedlung Cham-St. Andreas (Zugersee). Annuaire de la Société Suisse de Préhistoire et d'Archéologie. 69, pp. 55-62.

Jacomet, S., 1987. Ackerbau, Sammelwirschaft und Umwelt der egolzwiler und cortaillod-siedlungen. Ergebnisse samenanalytischer Untersuchungen. In: P. J. Suter, ed. Zürich "Kleiner Hafner". Tauchgrabungen 1981-1984, Berichte der Zürcher Denkmalpflege, Monographien 3. Zürich: Orell Füssli Verlag. pp. 144-166.

Jacomet, S., 1990. Veränderungen von Wirtschaft und Umwelt während des Spätneolothikums im westlichen Bodenseegebiet. Ergebnisse samenanalytischer Untersuchungen an einem Profilblock aus der Horgener Stratigraphie von Sipplingen-Osthafen (Tauchsondierung Ruoff 1980). In: Siedlungsarchäologie im Alpenvorland II, Forschungen und Berichte zur Vor- und Frühgeschichte in Baden-Württemberg, 37, Stuttgart: Landesamt für Denkmalpflege im Regierungspräsidium Stuttgart. pp. 295-351.

Jacomet S., 2004. Archäobotanische Grobuntersuchung verkohlter Getreideklumpen. In: U. Hügi & C. Michel-Tobler, eds. Oberrieden ZH-Riet – eine frühhorgenzeitliche Siedlung. Jahrbuch der Schweizerischen Gesellschaft für Urund Frühgeschichte. 87, pp. 21-23.

Jacomet, S., 2006a. Plant economy of the northern Alpine lake dwellings – 3500-2400 cal. BC. Environmental Archaeology. 11(1), pp. 65-85, doi.org/ 10.1179/174963106x97061

Jacomet, S., 2006b. Identification of cereal remains from archaeological sites, 2nd edition. Basel: IPAS Basel University.

Jacomet, S., 2007. Neolithic Plant Economies in the Northern Alpine Foreland from 5500-3500 cal BC. In: S. Colledge & J. Conolly, eds. The Origins and Spread of Domestic Plants in Southwest Asia and Europe. Walnut Creek: West Coast Press, pp. 221-258.

Jacomet, S., 2009. Plant economy and village life in Neolithic lake dwellings at the time of the Alpine Iceman. Vegetation History and Archaeobotany, 18(10.1007/s00334-007-0138-2), pp. 47-59.

Jacomet, S., 2012. Archaeobotany: analyses of plant remains from waterlogged sites. In: F. Menotti & A. O'Sullivan, eds. The Oxford Handbook of Wetland Archaeology. Oxford: Oxford University Press, pp. 497-514.

Jacomet, S., Brombacher, C. & Dick, M., 1989. Archäobotanik am Zürichsee. Ackerbau, Sammelwirtschaft und Umwelt von neolithischen und bronzezeitlichen Seeufersiedlungen im Raum Zürich. Ergebnisse von Untersuchungen pflanzlichen Makroreste der Jahre 1979-1988, Monographien der Kantonsarchäologie Zürich 7. Zürich: Orell Füssli Verlag.

Jacomet, S., Brombacher, C. & Schraner, E., 1999. Ackerbau und Sammelwirtschaft während der Bronze-und Eisenzeit in den östlichen Schweizer Alpen -vorläufige Ergebnisse. In: P. Della Casa, ed. Prehistoric alpine environment, society, and economy. Papers of the international colloquium PAESE '97 in Zurich. Universitätsforschungen zur prähistorischen Archäologie, Bonn, 55. pp. 231-244.

Jacomet, S. & Wagner, C., 1987. Verkohlte Pflanzenreste aus der Horgener Kulturschicht von Zug-Vorstadt 26. Jahrbuch der Schweizerischen Gesellschaft für Ur- Und Frühgeschichte. 70, pp. 175-180.

Jacquat, C., 1989. Hauterive-Champréveyres 2, Les Plantes de l'Age du Bronze, Contribution à l'histoire de l'environnement et de l'alimentation, Archéologie Neuchâteloise 8. Saint-Blaise: Ruau.

Jacquat, C. & Hafner, S., 1996, Pflanzliche Überreste. In: S. Hafner et al., eds. Die jungsteinzeitlichen Seeufersiedlungen von Hünenberg-Chämleten ZG, Antiqua, 28. Basel: Kantonsarchäologie Zug (Hrsg.), Société Suisse de Préhistoire et d'Archéologie. pp. 119-120.

Jesus, A. et al., 2021. Middle Neolithic farming of open-air sites in SE France: new insights from archaeobotanical investigations of three wells found at Les Bagnoles (L'Isle-sur-la-Sorgue, Dépt. Vaucluse, France). Vegetation History and Archaeobotany.

Jia, X. et al., 2016. How humans inhabited the Northeastern Tibetan Plateau during the Little Ice Age: A case study at Hualong County, Qinghai Province, China. Journal of Archaeological Science: Reports. 7, pp. 27-36. doi.org/10.1016/j.jasrep.2016.03.036.

Jones, G., 1984. Interpretation of archaeological plant remains: Ethnographic models from Greece. In: W. Van Ziest & W. A. Casparie, eds. Plants and Ancient Man - Studies in Paleoethnobotany. Rotterdam: A.A. Balkema. pp. 42-61.

Jones, G., 1987. A statistical approach to the archaeological identification of crop processing. Journal of Archaeological Science, 14(3), pp. 311-323.

Jones, G., 1990. The application of present day cereal processing studies to charred archaeological remains. Circaca, The Journal of the Association for Environmental Archaeology. 6, pp. 91-96.

Jones, G. & Halstead, P., 1995. Maslins, mixtures and monocrops: On the interpretation of archaeobotanical crop samples of heterogeneous composition. Journal of Archaeological Science. 22(1), pp. 103-144. doi.org/10.1016/S0305-4403(95)80168-5

Jones, G., Valamoti, S. M. & Charles, M., 2000. Early crop diversity: A “new” glume wheat from northern Greece. Vegetation History and Archaeobotany. 9(3), pp. 133-146. doi.org/10.1007/BF01299798

Jones, G. et al., 2010. Crops and weeds: the role of weed functional ecology in the identification of crop husbandry methods. Journal of Archaeological Science. 37(1). pp. 70-77. doi.org/10.1016/j.jas.2009.08.017

Kaplan, J. O. et al., 2011. Holocene carbon emissions as a result of anthropogenic land cover change. The Holocene. 21(5), doi.org/10.1177/0959683610386983

Karg, S., 1990. Pflanzliche Grossreste der jungsteinzeitlichen Ufersiedlungen von Allensbach-Strandbad (Kr. Konstanz): Wildpflanzen und Anbaufrüchte als stratigraphische, okologische und wirtschaftliche Informationsquellen in Siedlungsarchäologie im Alpenvorland II. Forschungen und Berichte zur Vor-und Frühgeschichte in Baden-Württemberg. 37, pp. 113-165.

Karg, S. & Markle, T. 2002. Continuity and changes in plant resources during the Neolithic period in western Switzerland. Vegetation History and Archaeobotany. 11(1-2), pp. 169-176.

Kerdy, M., Chiquet, P. & Schibler, J., 2018. Hunting, Husbandry, and Human-Environment Interactions in the Neolithic Lakeshore Sites of Western Switzerland. European Journal of Archaeology. 22(1), pp. 3-21. doi.org/10.1017/eaa.2018.32

Kirleis, W. & Fischer, E. 2014. Neolithic cultivation of tetraploid free threshing wheat in Denmark and Northern Germany: implications for crop diversity and societal dynamics of the Funnel Beaker Culture. Vegetation History and Archaeobotany. 23, pp. 81-96.

Klima, K. et al., 2020. Yield and Profitability of Crop Production in Mountain Less Favoured Areas. Agronomy. 10(700). doi.org/10.3390/agronomy10050700

Körber-Grohne, U., 1987. Nutzpflanzen in Deutschland. Stuttgart: Konrad Theiss.

Kreuz, A. & Marinova, E., 2017. Archaeobotanical evidence of crop growing and diet within the areas of the Karanovo and the Linear Pottery Cultures: a quantitative and qualitative approach. Vegetation History and Archaeobotany. 26, pp. 639–657. doi.org/10.1007/s00334-017-0643-x

Kreuz, A., Pomazi, P. & Banffy, E., 2020. Hungarian Neolithic landscapes, crops and diet – Signs of cultural decisions?. Quaternary International. 560-561, pp. 102-118. doi.org/10.1016/j.quaint.2020.06.008

Kreuz, A. & Schafer, E., 2002. A new archaeobotanical database program. Vegetation History and Archaeobotany, 11(1), pp. 177-180.

Lauk, R. & Lauk, E. 2008. Pea-oat intercrops are superior to pea-wheat and pea-barley intercrops. Acta Agriculturae Scandinavica, Section B — Soil & Plant Science. 58(2). pp. 139-144. doi.org/10.1080/09064710701412692

Le Bras-Goude, G., Herrscher, E., Vaquer, J., 2013. Funeral practices and foodstuff behaviour: What does eat meat mean? Stable isotope analysis of Middle Neolithic populations in the Languedoc region (France). Journal of Anthropological Archaeology. 32, pp.280 - 287. doi.org/10.1016/j.jaa.2012.01.005

Li, H., Renssen, H., Roche, D. M. & Miller, P. A., 2019. Modelling the vegetation response to the 8.2 ka bp cooling event in Europe and Northern Africa. Journal of Quaternary Science. 34(8), pp. 650-661. doi.org/10.1002/jqs.3157

Lodwick, L. A., 2019. Agendas for Archaeobotany in the 21st Century: data, dissemination and new directions. Internet Archaeology. 53, [Online].

Lundström-Baudais, K., 1978. Plant remains from a Swiss neolithic lakeshore site: Brise-Lames, Auvernier. Ber. Deutsch. Bot. Ges. 91. pp. 67-83.

Lundström-Baudais, K., 1986. Etude paléoethnobotanique de la station III de Clairvaux. In: P. Pétrequin, ed. Les sites littoraux néolithiques de Clairvaux-les-Lacs (Jura). I, Problématique générale. L'exemple de la station III. Paris: éditions de la maison des sciences de l'homme. pp. 310-391.

Lundström-Baudais, K., 1989a. Etude des paléosemences de la station II. In: P. Pétrequin, ed. Les sites littoraux néolithiques de Clairvaux-les-Lacs (Jura). II, le Néolithique moyen. Paris: éditions de la maison des sciences de l'homme. pp. 193-194.

Lundström-Baudais, K., 1989b. Les macrorestes végétaux du niveau V de la Motte-aux-Magnins. In: P. Pétrequin ed. Les sites littoraux néolithiques de Clairvaux-les-Lacs (Jura). II, le Néolithique moyen. Paris: éditions de la maison des sciences de l'homme. pp. 417-439.

Lundström-Baudais, K., 2005. Paléoethnobotanique à Charavines-Les Baigneurs. Récolte des éléments et méthodes d'étude (rapport de fouille 1982). In: A. Bocquet, ed. Site néolithique de Charavines-Les Baigneurs, Isère, France. Etudes scientifiques (1972-2005), Volume 2: Sédimentologie-Paléoenvironnement-Faune-Analyses complémentaires. Grenoble: Centre de Documentation de la Préhistoire Alpine. pp. 1-5.

Lundström-Baudais, K. & Martin, L., 2011. Les paléosemences des fosses néolithiques du Petit-Chasseur IV. In: M. Besse & M. Piguet, eds. Le site préhistorique du Petit-Chasseur à Sion (Valais, Suisse) 10. Un hameau du Néolithique moyen, Cahiers d'archéologie romande 124; Archaeologia Vallesiana 6. Lausanne-Martigny: C. A. R. pp. 261-267.

Macák et al., 2020. The Influence of Different Fertilization Strategies on the Grain Yield of Field Peas (Pisum sativum L.) under Conventional and Conservation Tillage. Agronomy. 10(1728). doi.org/10.3390/agronomy10111728

Macgregor, A. W. & Bhatty, R. S., 1993. Barley: chemistry and technology. Saint Paul: American Association of Cereal Chemists.

Magny, M., 2004. Holocene climate variability as reflected by mid-European lake-level fluctuations and its probable impact on prehistoric human settlements. Quaternary International, 113(1), pp. 65-79.

Maier, U., 1988. Botanische Untersuchungen zu Umwelt- und Wirtschaftsgeschichte der jungsteinzeitlichen Siedlung Ödenalhen im nördlichen Federseemoor. Jh. Ges. Naturkde. Württemberg. 143, pp. 149-176.

Maier, U., 1995. Moorstratigraphische und paläoethnobotanische Untersuchungen in der jundsteinzeitlichen Moorsiedlung. In: Siedlungsarchäologie im Alpenvorland III. Die neolithische

Moorsiedlung Ödenahlen, Forschungen und Berichte zur Vor- und Frühgeschichte in Baden-Württemberg, 46, Stuttgart: Kommissionsverlag-Konrad Theiss Verlag. pp. 143-253.

Maier, U., 1996. Morphological studies of free-threshing wheat ears from a Neolithic site in southwest Germany, and the history of the naked wheats. Vegetation History and Archaeobotany. 5(1-2), pp. 39-55.

Maier, U., 1996. Morphological studies of free-threshing wheat ears from a Neolithic site in southwest Germany, and the history of naked wheats. Vegetation History and Archaeobotany. 5, pp. 39-55.

Maier, U., 1999. Agricultural activities and land use in a Neolithic village around 3900 B.C.: Hornstaad Hörnle IA, Lake Constance, Germany. Vegetation History and Archaeobotany. 8, pp. 87-94.

Maier, U., 2001. Untersuchungen in der neolithischen Ufersiedlung Hornstaad-Hörnle IA am Bodensee. In: U. Maier & R. Vogt, eds., Siedlungsarchäologie im Alpenvorland VI. Botanische und pedologische Untersuchungen zur Ufersiedlung Hornstaad-Hörnle IA, Forschungen und Berichte zur Vor- und Frühgeschichte in Baden-Wüttemberg, 74. Stuttgart: Kommissionsverlag-Konrad Theiss Verlag. pp. 12-233.

Malleson, C. 2016. Informal intercropping of legumes with cereals? A re-assessment of clover abundance in ancient Egyptian cereal processing by-product assemblages: archaeobotanical investigations at Khentkawes town, Giza (2300–2100 BC). Vegetation History and Archaeobotany. 25, pp. 431-442. doi.org/10.1007/s00334-016-0559-x

Manen, C., 2002. Structure et identité des styles céramiques du Néolithique ancien entre Rhône et Èbre. Gallia Prehistoire. 44, pp. 121-165.

Manning, K. et al., 2013. The origins and spread of stock-keeping: the role of cultural and environmental influences on early Neolithic animal exploitation in Europe. Antiquity, 87(338), pp. 1046-1059.

Manning, K. et al., 2016. The Cultural Evolution of Neolithic Europe. EUROEVOL Dataset 1: Sites, Phases and Radiocarbon Data. Journal of Open Archaeology Data, 5.

Marini, L., Klimek, S. & Battisti, A., 2011. Mitigating the impacts of the decline of traditional farming on mountain landscapes and biodiversity: a case study in the European Alps. Environmental Science and Policy, 14(3), pp. 258-267.

Marinova, E. & Valamoti, S. M., 2014. Crop diversity and choices in the prehistory of SE Europe: the archaeobotanical evidence from Greece and Bulgaria. In: A. Chevalier, E. Marinova & L. Peña-Chocarro, eds. Plants and people: choices and diversity through time. Oxford: Oxbow. pp. 64-74.

Mariotti Lippi, M. et al., 2018. The Botanical Record of Archaeobotany Italian Network - BRAIN: a cooperative network, database and website. Flora Mediterranea. 28, pp. 365-376.

Märkle T. & Rösch M. 2008. Experiments on the effects of carbonization on some cultivated plants. Vegetation History and Archaeobotany. 17, pp. 257-263.

Martin, L., unpublished. In: Martin, L., 2020. Email to F. Greaves. Re. Site list of archaeobotanical data for NeoAlps Freya Project, 3 December 2020.

Martin, L., 2010. Agriculture et alimentation végétale en milieu montagnard au Néolithique: nouvelles données carpologiques dans les Alpes françaises du Nord. PhD thesis. Université de Paris 1 Panthéon-Sorbonne - Université de Bâle. http://tel.archives-ouvertes.fr/tel-00536982/fr/

Martin, L., 2011. Une bergerie néolithique dans le Vercors: analyse des macro-restes végétaux des "fumiers" fossiles de la Grande Rivoire (Isère, France). In: J. Wiethold, ed. Carpologia. Articles réunis à la mémoire de Karen Lundström-Baudais, Glux-en-Glenne, juin 2005, Bibracte, 20. Glux-en-Glenne: Centre archéologique européen. pp. 27-38.

Martin, L., 2014. Premier paysans des Alpes: Alimentation vegetale et argriculture au Neolithique. Rennes/Tours: Presses Universitaires de Rennes/Presses Universitaires François-Rabelais.

Martin, L., 2015. Plant economy and territory exploitation in the Alps during the Neolithic (5000-4200 cal BC): first results of archaeobotanical studies in the Valais (Switzerland). Vegetation History and Archaeobotany. 24(1), pp. 63-73. doi.org./10.1007/s00334-014-0490-y

Martin, A. C. & Barkley, W. D., 2000. Seed Identification Manual. New Jersey: The Blackburn Press.

Martin, L., Delhon, C., Argant, J. & Thiebault, S., 2011. Un aperçu de l'élevage au Néolithique par l'archéobotanique. L'exemple d'une bergerie dans le nord du Vercors. Ethnozootechnie. 91, pp. 37-46.

Martin, L., Jacomet, S. & Thiebault, S., 2008. Plant economy during the Neolithic in a mountain context: the case of ‘Le Chenet de Pierres’ in the French Alps (Bozel-Savoie). Vegetation History and Archaeobotany, 17(Suppl. 1), pp. S113-S122.

Martin, L. & Thiebault, S., 2010. L'if (Taxus baccata L.): historire et usage d'un arbre durant la Prehistoire recente. L'example du domaine alpin et circum-alpin. Antibes, Anthropobotanica.

Martin, L. et al., 2012. Plant exploitation and diet in altitude during Mesolithic and Neolithic: Archaeobotanical analysis from a hunting camp in the Chartreuse massif (l'Aulp-du-Seuil, Isère, France). Review of Palaeobotany and Palynology. 185, pp. 26-34. doi.org/10.1016/j.revpalbo.2012.07.011

Martin, L. et al., 2016. L’exploitation des ressources végétales durant le Chasséen : un bilan des données carpologiques en France entre 4400 et 3500 avant notre ère. In: T. Perrin, P. Chambon, J. F. Gibaja & G. Goude, eds. Le Chasséen, des Chasséens… Retour sur une culture nationale et ses parallèles, Sepulcres de fossa, Cortaillod, Lagozza, Paris - 18-20 novembre 2014. Toulouse: Archives d'Ecologie Prehistorique, pp. 259-272.

Martin, L. et al., 2019. De l’arolle ou du chêne? Mobilité verticale et exploitation des ressources végétales au Néolithique dans les Alpes occidentales. In: M. Deschamps et al., eds. La conquête de la montagne: des premières occupations humaines à l’anthropisation du milieu [en ligne]. Paris: Éditions du Comité des travaux historiques et scientifiques. doi.org/10.4000/books.cths.6677

Martinoli, D. & Jacomet, S., 2002. Pflanzenfunde aus Cham-Eslen. Erste Ergebnisse zur Versorgung mit pflanzlichen Nahrungsmitteln. Tugium. 18, pp. 76-77.

Matuzeviciute, G. D. et al., 2020. Southwest Asian cereal crops facilitated high-elevation agriculture in the central Tien Shan during the mid-third millennium BCE. PLoS ONE. 15(5), e0229372. doi.org/10.1371/journal.pone.0229372

Mauri, A., Davis, B. A. S., Collins, P. M. & Kaplan, J. O., 2015. The climate of Europe during the Holocene: a gridded pollen-based reconstruction and its multi-proxy evaluation. Quaternary Science Reviews. 112, pp. 109-127.

Mazzucco, N. et al., 2017. Harvest time: crop-reaping technologies and the Neolithisation of the Central Mediterranean. Antiquity, 91(356).

Mazzucco, N., Conte, I. C. & Gassiot, E., 2019. Lost in the mountains? The Cova del Sardo and the Neolithisation of the Southern Central Pyreness (fifth-third mill. Cal BC). Archaeological and Anthropological Sciences, 11, pp. 1461-1475. doi.org/10.1007/s12520-018-0603-0

Meilleur, B. A., 1985. Gens de montagne plantes & saisons. Savoirs écologiques de tradition à Termignon (Savoie). Le Monde alpin et rhodanien. Revue régionale d'ethnologie. 1, pp. 6-79.

Mermod, O., 2000. Die endneolithische Seeufersiedlung Saint-Blaise/Bains des dames NE. PhD thesis. Eidgenössische Technische Hochschule Zürich.

Mills, T., 2006. A Study Of European Cereal Frequency Change During The Iron Age And Roman Periods. Phd thesis. University of Sheffield.

Monjaret, C. & Del Bufalo, A., 2004. Sol, Climat et Culturs du Diois: Le risque de gel [Online]. l'Institut National Agronomique Paris-Grignon. Available at: https://tice.agroparistech.fr/coursenligne/courses/INIP/document/INIP/inipespv04/climat/risquege.htm. Accessed on July 7 2021

Motella De Carlo, S. & Venturino Gambari, M., 2004. Dalle foreste ai campi. Ambiente, risorse e economia nel Neolitico dell'Italia Nord-occidentale. In: D. Daudry, ed. Implantations rurales et économie agro-pastorale dans les Alpes de la Préhistoire au Moyen-âge, Cogne, 12-14 septembre 2003, Bulletin d'études préhistoriques et archéologiques alpines, Numéro spécial XV. Aoste: Société Valdôtaine de Préhistoire et d'Archéologie. pp. 125-142.

Mottes, E. & Rottoli, M., 2006. I resti carpologici del sito neolitico de la Vela di Trento (Campagne di scavo 1975 e 1976). In: A. Pessina & P. Visentini, eds. Preistoria dell'Italia settentrionale. Studi in ricordo di Bernardino Bagolini, Udine, settembre 2005. Udine: Edizioni del Museo Friulano di Storia Naturale. pp. 129-142.

Mottet, M. et al., 2011. Les Bâtiments Semi-Enterrés de Bramois. Un Habitat Du Néolithique Final En Valais (Suisse). Cahiers d'Archéologie Romande, 126 (Archaeologia Vallesiana, 8). Lausanne: Cahiers d'Archéologie Romande.

Mueller-Bieniek A., Pyzel J. & Kapcia M., 2018. Chenopodium Seeds in Open-Air Archaeological Sites - How to Not Throw the Baby Out with the Bathwater. Environmental Archaeology [Online.] pp. 1-13. doi.org/10.1080/14614103.2018.1536500

Mueller-Bieniek A. et al., 2019. The role of Chenopodium in the subsistence economy of pioneer agriculturalists on the northern frontier of the Linear Pottery culture in Kuyavia, central Poland. Journal of Archaeological Science. 111(3), pp. 105027. doi.org/10.1016/j.jas.2019.105027

Neef, R. et al., 2012. Digital Atlas of Economic Plants in Archaeology, Groningen Archaeological Studies 17, Eelde: Barkhuis.

Nicod, P-Y. et al., 2019. First Obsidian in the Northern French Alps during the Early Neolithic. Journal of Field Archaeology. 44(3), pp. 180-194.

Niffenegger, E. V., 1964. Chemical and physical characteristics of barley flour as related to its use in baked products. MSc thesis. Montana State University.

Nisbet, R., 1987. I resti vegetali carbonizzati. In: R. Nisbet & P. Biagi, eds. Balm'Chanto: un riparo sottoroccia dell'età del rame nelle Alpi cozie, Archeologia dell'Italia Settentrionale, 4. Como: Museo Civico Archeologico "Giovio" - edizioni New Press. pp. 103-105.

Nisbet, R., 1999. Un aperçu botanique sur la Préhistoire du Piémont: agriculture et forêts entre plaine et Alpes occidentales italiennes. In: A. Beeching, ed. Circulations et identités culturelles alpines à la fin de la préhistoire. Matériaux pour une étude, Programme CIRCALP 1997-1998, Travaux du Centre d'Archéologie Préhistorique de Valence, 2. Valence: Agence Rhône-Alpes pour les Sciences Humaines. pp. 39-48.

Nisbet, R., 2006. Agricoltura del Neolitico antico alle Arene Candide (Savona). In: N. Cucuzza & M. Medri, eds. Archeologie. Studi in onore di Tiziano Mannoni. Bari: Edipuglia. pp. 331-335.

Nisbet, R., 2008. Environment and agriculture in the early Neolithic of the Arene Candide (Liguria). In: G. Fiorantino & D. Magri, eds. Charcoals from the Past: Cultural and Palaeoenvironmental Implications, Cavallino-Lecce (Italy), June 28th-July 1st 2004, BAR International Series, 1807. pp. 193-198.

Oeggl, K., 2000. The diet of Iceman. In: S. Bortenschlager & K. Oeggl, eds. The Iceman and his natural environment. Palaeobotanical results, The Man in the Ice, 4. Wien: Springer-Verlag. pp. 89-109.

Oeggl, K. & Schoch, W. H., 1995. Neolithic plant remains discovered together with a mummified corpse ("Homo tyrolensis") in the Tyrolean Alps. In: H. Kroll & R. Pasternak, eds. Res archaeobotanicae. Kiel: Oetker Voges Verlag. pp. 165-193.

Olivier, J. M. et al., 2009. The Rhône River Basin. In: K. Tockner, U. Uehlinger & C. T. Robinson, eds. Rivers of Europe. Cambridge: Academic Press, pp. 247-295.

Orengo, H. A. & Livarda, A., 2016. The seeds of commerce: A network analysis-based approach to the Romano-British transport system. Journal of Archaeological Science. 66, pp. 21-35.

Ozenda, P., 1988. Die Vegetation der Alpen im europäischen Gebirgsraum. Stuttgart: Fischer.

Pala, M., Stockle, C. O. & Harris, H. C., 1996. Simulation of Durum wheat (Triticum turgidum ssp. durum) growth under different water and nitrogen regimes in a Mediterranean environment using CropSyst. Agricultural Systems. 51, pp. 147-163. doi.org/10.1016/0308-521X(95)00043-5

Pals, J. P. & Voorips, A., 1979. Seed, fruits and charcoals from two prehistoric sites in northern Italy. Archaeo-Physika. 8, pp. 217-235.

Paz, V., 2005. Rock Shelters, Caves and Archaeobotany in Island Southeast Asia. Asian Perspectives. 44(1), pp. 107-118.

Pecher, C., Tasser, E. & Tappeiner, U., 2011. Definition of the potential treeline in the European Alps and its benefit for sustainability monitoring. Ecological Indicators, 11(2), pp. 438-447.

Peña-Chocarro L. & Zapata, L., 2003. Post-harvesting processing of hulled wheats. An ethnoarchaeological approach. In: P. C. Anderson et al., eds. Le traitement des récoltes: un regard sur la diversité, du Néolithique au présent. Actes des XXIIIe rencontres Internationales d'archéologie et d'histoire d'Antibes, 17-19 octobre 2002. Antibes: Éditions APDCA. pp. 99-113.

Peña-Chocarro, L. et al., 2009. Einkorn (Triticum monococcum L) Cultivation in Mountain Communities of the Western Rif (Morocco): An Ethnoarchaeological Project. In: A. S. Fairnbairn & E. Heiss, eds. From foragers to farmers: Papers in honour of Gordon C. Hillman. Oxford: Oxbow Books. pp. 103-111.

Perrin, T., 2003. Mesolithic and Neolithic cultures co-existing in the upper Rhône. Antiquity, 77(298), pp. 732-739.

Perrin, T., Sordoillet, D. & Voruz, J. L., 2002. L’habitat en grotte au Néolithique : vers une estimation de l’intensité des occupationsThe habitat into cave during the Neolithic: towards an estimation of the intensity of the occupations. L'Anthropologie. 106(3), pp. 423-433. doi.org/10.1016/S0003-5521(02)01121-4

Pessina, A., 2001. Nouvelles données sur le Néolithique ancien de l'Italie Nord-orientale. In: P. Marinval, ed. Histoires d'hommes, histoires de plantes. Hommages au professeur Jean Erroux, Rencontres d'archéobotanique de Toulouse, Mémoire de plantes, 1. Monique Mergoil-Centre d'anthropologie. Drémil-Lafage: Éditions Mergoil. pp. 105-118.

Pessina, A. & Rottoli, M., 1996. New evidence on the earliest farming cultures in northern Italy: archaeological and palaeobotanical data. In: Porocilo o raziskovanju paleolitika, neolitika in eneolitika v Sloveniji. Ljubljana: Oddelek za arheologijo Filozofske fakultete Univerze v Llublijani. pp. 77-103.

Phillips, P., 1983. The Middle Neolithic in Southern France: Chasseen Farming and Culture Process. Oxford: BAR International Series.

Piening, U., 1981. Die verkohlten Kulturpflanzenreste aus den Proben der Cortaillod- und Horgener Kultur. In: B. Ammann et al., eds. Botanische Untersuchungen. Ergebnisse der Pollen- und Makrorestanalysen zu Vegetation, Ackerbau und Sammelwirschaft der Cortaillod- und Horgener Siedlungen, Die neolithischen Ufersiedlungen von Twann, 14. Bern: Staatlicher Lehrmittelverlag. pp. 69-116.

Piening, U., 1988. Neolithische und hallstattzeitliche Pflanzenreste aus Freiberg-Geisingen (Kreis Ludwigsburg). In: H. Küster, ed. Der prähistorische Mensch und seine Umwelt, Festschrift für Udelgard Körber-Grohne zum 65. Geburtstag, Forschungen und Berichte zur Vor- und Frühgeschichte in Baden-Württemberg, 31. Stuttgart: Kommissionsverlag Konrad Theiss Verlag. pp. 213-228.

Pini, R., 2004. Late neolithic vegetation history at the pile-dwelling site of Palù di Livenza (northeastern Italy). Journal of Quaternary Science. 19(8), pp. 769-781.

Prats, G., Antolin, F. & Alonso, N., 2020. Household storage, surplus and supra-household storage in prehistoric and protohistoric societies of the Western Mediterranean. PLoSOne. 15(9), e0238237. doi.org/10.1371/journal.pone.0238237

Proszak-Miasik, D. & Rabczak, C., 2019. The use of forest waste in the energy sector. IOP Conference Series: Materials Science and Engineering. 603, 052092. doi.org/10.1088/1757-899X/603/5/052092

Rasmussen, P., 1993. Analysis of goat/sheep faeces from Egolzwil 3, Switzerland: evidence for branch and twig foddering of livestock in the Neolithic. Journal of Archaeological Science. 20(5), pp. 479-502.

Reed, K., 2015. From the field to the hearth: plant remains from Neolithic Croatia (ca. 6000–4000 cal BC). Vegetation History and Archaeobotany. 24, pp. 601-619. doi.org/10.1007/s00334-015-0513-3

Reed K. et al., 2019. Grains from ear to ear: the morphology of spelt and free-threshing wheat from Roman Mursa (Osijek), Croatia. Vegetation History and Archaeobotany. 28. pp. 623–634. doi.org/10.1007/s00334-019-00719-4

Rey, P-J. & Marguet, A., 2016. Caractérisation technique et culturelle de la céramique du site lacustre de Conjux 3 (lac du Bourget, Savoie): le Néolithique final des avant-pays savoyards en question. Bulletin de la Société préhistorique française. 113(1), pp. 57-94.

Ricq-de Bouard, M. & Fedele, F., 1993. Neolithic rock resources across the western alps: Circulation data and models. Geoarchaeology. 8(1), pp. 1-22. doi.org/10.1002/gea.3340080102

Riehl S. (1993). Botanische Großreste aus einer neolithischen Profilabfolge -Die horgenerzeitliche Seeufersiedlung Wangen/Bodensee. Unpublished Master's thesis. University of Tübingen.

Riehl, S., 2019. Barley in Archaeology and Early History [Online]. Oxford Research Encyclopedia of Environmental Science. Available at: https://oxfordre.com/environmentalscience/view/10.1093/acrefore/9780199389414.001.0001/acrefore-9780199389414-e-219. : Accessed on 23 June 2021

Rigert, E. et al., 2005a. Die Epi-Rössener Siedlung von Sevelen SG-Pfäfersbüel. Annuaire de la Société Suisse de Préhistoire et d'Archéologie. 88, pp. 41-86.

Rigert, E. et al., 2005b. Eine Fundstelle der Glockenbecherzeit in Wetzichon ZH-Kempten, Tösstalstrasse 32-36. Annuaire de la Société Suisse de Préhistoire et d'Archéologie. 88, pp. 87-118.

Rivollat, M. et al., 2015. When the Waves of European Neolithization Met: First Paleogenetic Evidence from Early Farmers in the Southern Paris Basin. PLoS One, 10(4), p. doi.org/10.1371/journal.pone.0125521.

Robinson, D. & Rasmussen, P., 1989. Botanical investigations at the neolithic lake village at Weier, North east Switzerland: leaf hay and cereals as animal fodder. In: A. Milles, D. Williams & N. Gardner, eds. The Beginnings of Agriculture, BAR International Series, 496. pp. 149-163.

Rosch, M., 1990. Botanische Untersuchungen in spätneolithischen Ufersiedlungen von Wallhausen und Dingelsdorf am Überlinger See, Kreis Konstanz. Siedlungsarchäologie im Alpenvorland II. Forschungen und Berichte zur Vor- und Frühgeschichte in Baden-Württemberg 37, pp. 227–266.

Rottoli, M., 1999. I resti vegetali di Sammardenchia-Cûeis (Udine), insediamento del Neolitico antico. In: A. Ferrari & A. Pessina, eds. Sammardenchia-Cûeis. Contributi per conoscenza di una comunità del primo Neolitico, Pubblicazione 41. Udine: Edizioni del Museo Friulano di Storia Naturale. pp. 307-326.

Rottoli, M. & Castiglioni, E., 2009. Prehistory of plant growing and collecting in northern Italy, based on seed remains from the Early Neolithic to the Chalcolithic (c.5600-2100 cal BC). Vegetation History and Archaeobotany. 18, pp. 91-103.

Rottoli, M. & Pessina, A., 2007. Neolithic agriculture in Italy: an update of archaeobotanical data with particular emphasis on northern settlements. In: S. Colledge & J. Conolly, eds. The Origins and Spread of Domestic Plants in Southwest Asia and Europe. Walnut Creek: West Coast Press, pp. 141-154.

Salavert, A., 2011. Plant economy of the first farmers of central Belgium (Linearbandkeramik, 5200-5000 B.C.). Vegetation History and Archaeobotany. 20(5), pp. 321-332.

Sampietro, M. L. et al., 2007. Palaeogenetic evidence supports a dual model of Neolithic spreading into Europe. Proceedings of the Royal Society B: Biological Sciences, 274(1622), p. 2161–2167.

Sauvan, E., 1921. L'évolution économique du Haut-Diois. Revue de Géographie Alpine, 9(4), pp. 521-624.

Savard, M., 2000. Etude de l'assemblage carpologique de la Baume de Fontbrégoua (Var) du Paléolithique final au Chasséen récent, Mémoire de DEA "Environement et Archéologie" sous la direction de Ph. Marinval. Paris: Université de Paris 1 et de Paris X.

Schaal, C., 2002. Paléocarpologie de la station 19 du lac de Chalain (Jura) au IIIè millénaire av. J.-C. In: Internéo 4-2002, Paris, 16 nov. 2002. Paris: Association pour les études interrégionales sur le Néolithique-Société Préhistorique Française. pp. 59-68.

Schaal, C. & Petrequin, P., 2015. Approche archéobotanique du Néolithique moyen de Clairvaux. In: P. Petrequin & A-M. Petrequin, eds. Clairvaux et le "Néolithique Moyen Bourguignon. Besançon: Presse

Universitaire de Franche-Comté, Centre de Recherche Archéologique de la Vallée de l'Ain. pp. 1193-1278.

Schibler, J. & Jacomet, S., 2010. Short climatic fluctuations and their impact on human economies and societies: The potential of the Neolithic lake shore settlements in the Alpine foreland. Environmental Archaeology. 15(2), pp. 173-182. doi.org/10.1179/146141010X12640787648856

Schwörer, C. et al., 2015. Early human impact (5000-3000 BC) affects mountain forest dynamics in the Alps. Journal of Ecology. 103(2), pp.281-295, doi.org/10.1111?1365-2745.12354

Sharples, J. J., 2018. Foehn winds. In: S. L. Manzello, ed. Encyclopedia of Wildfires and Wildland-Urban Interface (WUI) Fires. Cham: Springer Nature Switzerland AG. doi.org/10.1007/978-3-319-51727-8_71-1

Siebke et al., 2020. Crops vs. animals: regional differences in subsistence strategies of Swiss Neolithic farmers revealed by stable isotopes. Archaeological and Anthropological Sciences. 12, 235. doi.org/10.1007/s12520-020-01122-1

Starnini, E., Biagi, P. & Mazzucco, N., 2018. The beginning of the Neolithic in the Po Plain (northern Italy): Problems and perspectives. Quaternary International. 470, pp. 301-317.

Starnini, E., Ghisotti, F., Girod, A. & Nisbet, R., 2000. Nuovi dati sul Neolitico antico della pianura padana centrale dal sito di Isorella (Brescia). In: A. Pessina & G. Muscio, eds. La Neolitizzazione tra Oriente e Occidente, Udine, 23-24 aprile 1999. Udine: Edizioni del Museo Friulano di Storia Naturale. pp. 231-255.

Stokes, P. & Rowley-Conwy, P., 2002. Iron age cultigen? Experimental return rates for fat hen (*Chenopodium album L.*). Environmental Archaeology. 7, pp. 95-99.

Styring, A. et al., 2016. Cultivation of choice: new insights into farming practices at Neolithic lakeshore sites. Antiquity, 90(349), pp. 95-110.

Theurillat, J. P. & Guisan, A., 2001. Potential Impact of Climate Change on Vegetation in the European Alps: A Review. Climatic Change. 50, pp. 77-109.

Theurillat, J. P., et al., 1998. Sensitivity of Plant and Soils Ecosystems of the Alps to Climate Change. In: P. Cebon, U. Dahinden, H. C., Davies, D., Imboden, C. C., and Jaeger, eds. Views from the Alps: Regional Perspectives on Climate Change. Cambridge, MA: MIT Press. pp. 225-308.

Thiebault, S., 1999. Anthracologie de quatre sites d'altitude prealpins. In: A. Beeching, ed. Circulations et identités culturelles alpines à la fin de la préhistoire. Travaux du Centre D'archéologie Préhistorique de Valence. Valence: Agence Rhône Alpes pour les Sciences humaines, pp. 39-47.

Thiebault, S., Terral, J. F. & Marinval, P., 2004. Gestion et exploitation d'un territoire au Néolithique : le cas de Giribaldi (Nice, Alpes-Maritimes). L'apport des macrorestes végétaux. In: P. Bodu & C. Constantin, eds. Approches fonctionnelles en Préhistoire, Nanterre, 24-26 novembre 2000. Paris: Société Préhistorique Française. pp. 325-333.

Thirault, E. 2005. The politics of supply: The Neolithic axe industry in Alpine Europe. Antiquity. 75(303), pp. 34-50. doi.org/10.1017/S0003598X00113687

Tison, J. M. & de Foucault, B. 2014. Flora Gallica: Flore de France. Mèze: Biotope.

Treffort, J. M., Nicord, P. Y., Excoffier-Buisson, R., 1999. La Balme à Gontran à Chaley (Ain): du Néolithique moyen au haut Moyen Age dans une cavité du Jura méridional. Revue archéologique de l'Est. 50, pp. 53-118.

Trefny, M. & Jennings, B., 2017. Inter-regional Contacts During the First Millenium B.C. in Europe: Proceedings from the Session Organized During the 19th Meeting of European Association of Archaeologists, Held in Pilsen (5th-9th September 2013). Hradec Kralove: University of Hradec Kralove.

Tresset, V. & Vigne, J. D., 2011. Last hunter-gatherers and first farmers of Europe. Comptes Rendus Biologies, 334(3), pp. 182-189.

Troccoli, A. & Codianni, P., 2005. Appropriate seeding rate for einkorn, emmer, and spelt grown under rainfed condition in Southern Italy. European Journal of Agronomy. 22(3), pp. 293-300. doi.org/ 10.1016/j.eja.2004.04.003

Turland, N. J. et al. (eds.) 2018. International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code) adopted by the Nineteenth International Botanical Congress Shenzhen, China, July 2017. Regnum Vegetabile 159. Glashütten: Koeltz Botanical Books. doi.org/10.12705/Code.2018

Valamoti, S. M., Moniaki, A. & Karathanou, A. 2011. An investigation of processing and consumption of pulses among prehistoric societies: archaeobotanical, experimental and ethnographic evidence from Greece. Vegetation History and Archaeobotany. 20, pp. 381-396.

Vander Linden, M., 2011. To Tame a Land: Archaeological Cultures and the Spread of the Neolithic in Western Europe. In: B. W. Roberts & M. Vander Linden, eds. Investigating Archaeological Cultures: Material Culture, Variability, and Trasmission. New York: Springer Science+Business Media, pp. 289-319.

Vandorpe, P., 2010. Un stock de céréales du Néolithique final. In: M. Mauvilly, ed. Villeneuve/La Baume: un exemple de fréquentation des abris naturels fribourgeois. Cahiers d'Archéologie Fribourgeoise. 12, pp. 17.

van Zeit, W. & Boekschoten-van Helsdingen, A. M., 1991. Samen und Früchte aus Niederwil. In: H. T. Waterbolk & W. van Zeist, eds. Niederwil, eine Siedlung der Pfyner Kultur. Band III: Naturwissenschaftliche Untersuchungen. Bern: Paul Haupt. pp. 49-112.

Vaquer, J., 1975. La ceramique chasseenne du Languedoc. Carcassonne: Laboratoire de prehistoire et de palethnologie, Depot de fouilles archaeologiques.

Vérot-Bourrely A. et al., 1997. Histoire du paysage d'une vallée du Jura méridional à l'Holocène. Le site archéologique de "Derrière-le-Château" (communes de Géovreissiat et de Montréal-la-Cluse, Ain). In: J. Burnouf, J. P. Bravard & G. Chouquer, eds. La Dynamique des paysages protohistoriques, antiques, médiévaux et modernes, 17-19 octobre 1996. Sophia Antipolis: Éditions APDCA. pp. 319-350.

Villaret-von Rochow, M., 1967. Frucht- und Samenreste aus der neolithischen Station Seeberg, Burgäschisee-Süd. In: J. Boessneck, J. P. Jequier & H. R. Stampfli, eds. Seeberg Burgäschisee-Süd, Teil 4: Chronologie und Umwelt. Bern: Verlag Stämpfli & Cie. pp. 21-63.

Vital, J. et al., 2004. La grotte des Crapauds à Donzère (Drôme): une halte-bergerie de l'Age du Fer. Revue archéologique de Narbonnaise, 20. pp. 389-401. doi.org/10.3406/ran.1987.1316

von Burg, A., 2002. Die Glockenbecherkultur auf dem Plateau von Bevaix. Archäologie der Schweiz. 25, 48-57.

von Glasenapp, M. & Thornton, T. F., 2011. Traditional Ecological Knowledge of Swiss Alpine Farmers and their Resilience to Socioecological Change. Human Ecology. 39(6), pp. 769-781.

Voruz, J. L., 1990. Chronologie de la neolithisation alpine. Colloque sur les Alpes dans l'Antique, 5, Pila Aoste, septembre 1987, Bulletin d'etudes prehistoriques et archaeologiques alpines. 1, pp. 63-108.

Voruz, J. L., 2004. La séquence néolithique de la grotte du Gardon (Ain). Bulletin de la Société préhistorique française. 101(4), pp. 827-866.

Voruz, J. L., Nicod, P. Y. & De Ceuninck, G., 1995. Les chronologies neolithiques dans le Bassin rhodanien: un bilan. In: J. L. Voruz, ed. Chronologies néolithiques: de 6000 a 2000 notre ere dans le Bassin rhodanien. Amberieu-en-Bugey: Societe prehistorique rhodanienne, pp. 381-404.

Wales, N. & Kistler, L., 2019. Extraction of Ancient DNA from Plant Remains. In: B. Shapiro, et al. (eds.) Ancient DNA: Methods and Protocols 1963 (Methods in Molecular Biology 1963). Totowa: Springer Humana Press. pp. 45-55.

Walsh, K., 2005. Risk and marginality at high altitudes: new interpretations from fieldwork on the Faravel Plateau, Hautes-Alpes. Antiquity, 304(79), pp. 289-305.

Walsh, K., 2014. The Archaeology of Mediterranean Landscapes. New York: Cambridge University Press.

Walsh, K. et al., 2014. A historical ecology of the Ecrins (Southern French Alps): Archaeology and palaeoecology of the Mesolithic to the Medieval period. Quaternary International. 353, pp. 52-73.

Walsh, K. & Giguet-Covex, C., 2019. A History of Human Exploitation of Alpine Regions. In: Reference Module in Earth Systems and Environmental Sciences. Elsevier, [Online].

Walsh, K. & Mocci, F., 2011. Mobility in the Mountains: Late Third and Second Millennia Alpine Societies' Engagements with the High-Altitude Zones in the Southern French Alps. European Journal of Archaeology, 14(1-2), pp. 88-115.

Walsh, K., Mocci, F. & Palet Martinez, J., 2007. Nine thousand years of human/landscape dynamics in a high altitude zone in the southern French Alps (Parc National des Ecrins, Hautes-Alpes). Preistorica Alpina. 42, pp. 9-22.

Walsh, K., Richer, R. & de Beaulieu, J. L., 2006. Attitudes to altitude: changing meanings and perceptions within a 'marginal' Alpine landscape – the integration of palaeoecological and archaeological data in a high-altitude landscape in the French Alps. World Archaeology, 38(3), pp. 436-454. doi.org/10.1080/00438240600813392

Weisdorf, J. L., 2005. From Foraging To Farming: Explaining The Neolithic Revolution. Journal of Economic Surveys, 19(4), pp. 561-586.

Williams, J. T., 1963. Chenopodium album L. Journal of Ecology. 51(3), pp. 711-725. doi.org/10.2307/2257758

Willigen, S., 2018. Between Cardial and Linearbandkeramik: From no-man's-land to communication sphere. Quaternary International, 470(B), pp. 333-352.

Wuthrich, S., 2003. Saint-Aubin/Derrière la Croix: un complexe mégalithique durant le Néolithique moyen et final (Archéologie neuchâteloise, 29; 2 vol.). Neuchâtel: Service et musée cantonal d'archéologie.

Zibulski, P., 2017. Archaeobotanical investigations on two Neolithic wetland settlements in the Swiss foothills of the Alps, with special consideration of the twigs. PhD thesis. University of Basel.

Zohary, D., Hopf, M. & Weiss, E. 2012. Domestication of Plants in the Old World. Oxford: Oxford University Press.

Zvelebil, M., 2004. Who were we 6000 years ago? In search of prehistoric identities. In: M. Jones, ed. Traces of ancestry: studies in honour of Colin Renfrew. Cambridge: McDonald Institute Monographs, pp. 41-60.