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Natural environment and human settlement in later prehistoric Central Europe

(Abstract) by Bruce Michael

Worthington Albert, 2004

This work analyses the adaptive relationship between early farming settlement and natural environment in Central Europe between 3500 (cal.) BC and AD 400. The primary data-base consists of fourteen alluvial and archaeological pollen sites from the Czech and Slovak Republics. Primary analyses trace divergent vegetation histories in temperate (Hercynian) and continental (Pannonian) bio-geographic zones, and focus on human impact on these biomes. Syn-anthropic impact is registered in agricultural floral expansion, deforestation and dry-steppe formation, vectors which are equated with higher farming population densities. A methodological review allows for an assessment of land-areas represented at the fourteen pollen sites, while the understanding of pollen taphonomy on alluvial accretion surfaces is advanced at the principal site of Vranský potok.

Secondary analyses then reconstruct a comparative settlement and climate history in the later Holocene of Central Europe. Importantly, settlement reconstructions exhibit a cyclical pattern of growth and decline at century-level time-scales. When compared to the primary geo-botanical record, an alignment of settlement maxima with high levels of human impact on flora and soils affirms the reality of this archaeologically perceived settlement cycle. A similar alignment of agricultural maxima with with favourable agro-climate furthermore implies that food production is generally limited by secular climate change, while an anthropogenic limitation of agriculture through dry-steppe formation is supported in the Pannonian geo-botanical data-base.

Ultimately, a theoretical treatment of the adaptation concept is attempted after cultural ecologic data presented. Beyond subsistence, this treatment incorporates the ecologic constructs of direct competition (after evidence for warfare) and mean mating-distance (after population reconstructions). Dia-chronic patterns of cultural distributions suggest that an early linkage of archaeological cultures with distinctive environmental zones is reduced as evidence for warfare and socio-political complexity becomes pervasive. Cultural adaptation thus becomes less a function of optimising subsistence and more one of group defense-population integration.

Natural environment and human settlement in later prehistoric Central Europe

Volume I of II: main text

Thesis by Bruce Michael Worthington Albert, in submission for a Doctorate of Philosophy,
Department of Archaeology, University of Durham, 2004

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13 JUN 2005

Table of contents

List of figures

ERRATA SLIP

The following typographical errors in the Bibliography (Vol. II) should be noted:-

p. 20: Lünning J = Lüning J.

p. 21: in Mateiciucova 2001, Niderosterreich = Niederösterreich;

p. 30: in Schreiber 1973, Torteneti Muzeum = Történeti Múzeum.

Preface

This work represents the culmination of original, primary palynological research of multiple alluvial and archaeological sites in the Czech and Slovak Republics (formerly, Czechoslovakia) between 1992 and 1996 (see Chapters 3, 6 and 7). This primary field and laboratory work was done in conjunction with extensive natural (see Chapters 4 and 5) and cultural historical background research (see Chapters 8-12) between 1992 and 1997. A limited amount of similar background research also took place during the main writing of the thesis between 1997 and 2002. Since 2002, the original draft of the thesis has undergone significant technical revisions in reaching the present (2004) format.

In its primary scope, the thesis represents the first large-scale and systematic attempt to employ alluvial sites in pollen analysis within the region of the Czech and Slovak Republics. The areas of focal geo-botanical study are also areas of significant prior archaeological research. This latter cultural historical comparative data-base has been closely integrated into the primary pollen study. Major theoretical and methodological aspects of the regional archaeology (of Poland, Germany, Hungary and Austria, as well as the Czech and Slovak Republics) have also been incorporated into the direction of the research program (see Chapters 2 and 13). Original Czech and Slovak sources, as well as unpublished material and extensive personal communications have been employed in the secondary research.

Regarding the secondary research, a relative poverty of source material post-dating 1995 might be noted by the reader. This constraint was imposed by limited access on the part of the author to primary library materials in the United States following the completion of primary field and laboratory work upon which this thesis is based.

Ultimately, an attempt was made to understand the later prehistory of Central Europe in terms of human ecology (see Chapters 2 and 14). Adaptations of population biological concepts to human cultural situations was made with a view to complexities of the human cognitive condition. Human culture and its effects on adaptation are addressed. Such a broad theoretical approach was made possible due to the large body of research which has taken place in the study region since the last World War. The latter theoretical approach was formulated during the earlier part of the thesis study, between 1992 and 1995.

1. Introduction

A natural and cultural history of early agrarian communities in Central Europe forms the central subject matter of this work. Primary research is comprised of pollen analyses of cored alluvial sediments and sediments from archaeological sites in the Czech and Slovak Republics, geo-botanical analyses which reconstruct natural conditions of later prehistoric agriculture as well as the impact on the environment consequent to agriculture. Syntheses of secondary palaeo-climatic, geo-botanical and archaeological evidence in Central Europe together with primary pollen analyses are then used to reconstruct pre- and proto-historic cultural ecology from (ca.) 40/3900 cal. (3300 uncal.) BC to AD 400.

Two bio-geographic zones are encompassed in this work: a continental Pannonian zone of the Northwest Carpathian Basin or West Slovakia and South Moravia, and a temperate Hercynian zone of Bohemia and North Moravia, between which comparative vegetation and settlement histories are examined from Eneolithic times until the Roman Iron Age (Fig. 145). In the beginning, it is inferred that the first farmers settle in a land of forests only minimally inhabited by hunter-gatherers. By Roman times, expansive steppes are recorded in much of the Carpathian Basin, while Hercynia would appear to support a more aforested natural environment (cf. Fig. 146).

Primary vs. secondary research

Primary research of agricultural and general vegetation history takes the form of pollen analyses from fourteen alluvial and archaeological sites in Bohemia, Moravia and Slovakia (Fig. 148). Alluvial pollen cores have been obtained from areas of known prehistoric settlement, and reflect cultural impact on natural flora and agricultural soils. Archaeo-palynological samples may reflect more local vegetation conditions after cultural impacts. A systematic and periodic review of settlement history, with foci on demography, agricultural technology, social structure and possible cognitive aspects of later prehistoric adaptation is made to place natural historic events into cultural ecological perspective. To this end, the material and ideal conditions of somatic and reproductive adaptation are also defined. Ecological differences between the temperate west and the continental east provide further analytical contrasts in assessing prehistoric adaptations.

Geologic and biotic provinces

The territory of the Czech and Slovak Republics is highly varied in geology and bio-geography (see Figs. 145 and 147). Within Hercynia (Bohemia and North Moravia), differentially-eroded belts of resistant, Palaeozoic metamorphic and igneous rocks make-up the Šumava uplands of South Bohemia, as well as the mountainous ring of the Ore and Südeten ranges to the north. Geologically, the lowlands of North Bohemia are comprised of both sandstone and limestone strata, through which igneous intrusions have developed at its centre, in the Středo-Hoří. Atop these sedimentary deposits lie the loess-based soils of Bohemia, a lowland zone (at 200 to 350 mamsl) of (ca.) 30,000 km^2 extent. Gradual tectonic uplift in Hercynia has also led to the deep incision of river valleys in which this loess is lain. As a result of secondary deposition, higher-order valleys near major river systems have a far broader distribution of loessic soil cover than lower-order valleys of streams near their respective watersheds. The smaller fluvial systems of Bohemia thus give rise to a highly variegated landscape of little valley systems. Only on the flood plains of the Middle Elbe and Lower Ohře are broad flatlands to be encountered.

In the Northwest Carpathian Basin (South Moravia and West Slovakia), geologic phenomena are of quite a different character. Here tectonic uplift is less significant, or non-existent. The lowland zone (125 to 300 mamsl) within the Carpathian Basin is also more extensive (greater than 50,000, km^2), and is covered by thicker deposits of loess, as well as Danubian alluvium, above a Mesozoic limestone substratum which gives rise to soils of a calcareous character. Bounding this lowland Danubian zone to the north are the high mountains of the Tatras, a relatively young mountain zone of igneous and metamorphic rock, cut by rivers into deep valleys flowing southwards into the Danube. These upland places also witness extensive if pulsatory prehistoric settlement.

The floral bio-geography of the Czech and Slovak Republics as determined by geology, mean altitude and climate recognises three main zones: a Hercynian zone of Bohemia and North Moravia, a Pannonian zone of South Moravia and South Slovakia and an eastern Tatran zone in the Carpathians. The Hercynian zone enjoys a temperate continental climate generally free from moisture deficit except in the driest lowland areas which are a centre of prehistoric settlement (the "Little Pannonian" sub-zone of "degraded", possibly anthropogenic czernozems). The Pannonian zone suffers from periodic late summer moisture deficits, although milder winters are also enjoyed. It is likely that climate within the Tatran zone has been variable throughout prehistory, as dependent on variations in the adiabatic lapse rate (this rate fluctuates according to the penetration of Atlantic air-masses and the relative activity of late summer anti-cyclones). With more effective moisture, air masses ascending into the Tatras will carry more heat to higher altitudes.

Differences in altitude have also served to exaggerate longitudinal differences in precipitation, with the low-lying Carpathian Basin experiencing greater effective evaporation as well as greater insolation from moisture-bearing Atlantic air masses. This Pannonian zone includes flora of the steppe and alluvial woodlands of *Abies* and *Picea*. In contrast, Hercynian climax vegetation consists of mixed-oak woodlands in the lowlands, with upland forests of *Abies* and *Picea*. The Tatran zone also includes taxa Asian derivation (e.g. *Acer tartaric*) which periodically penetrate westwards.

Central European archaeological sequence

This work focuses on temporal divisions of prehistory of the Eneolithic, Bronze Age, Iron Age and Roman Iron Age . Secular periods of (ca.) 200-300 ^{14}C year duration are recognized within this post-Neolithic focus, producing seventeen temporal units of analysis. According to bio-geography, these periods are enumerated as follows:

Table 1.1. Archaeological sequence of prehistoric agrarian cultural units in the Czech and Slovak Republics. (a) = secondary units, a/b = successive units. a;b = multiple units.

Epoch and period (approx. cal.)	*Hercynia*	*Pannonia*
Early Eneolithic		
1. 41/000 to 38/700 cal. BC	Early Baalberg (Michelsberg II/III)	Fürchenstich (Early Baalberg)
2. 38/700 to 35/3400 cal. BC	Late Baalberg/Early Salzmünde (Michelsberg III/IV)	Late Baalberg/Early Channeled Ware

Table 1.1. continued.

Epoch	*Hercynia*	*Pannonia*
Middle and Late Eneolithic		
3. 35/3400 to 32/100 cal. BC	Late Salzmünde (Late Channeled Ware)	Late Channeled Ware
4. 32/3100 to 2750 cal. BC	Řivnáč Culture; Cham Culture (Globular Amphora Culture)	Jevišovice Culture;Bošáca Group
5. 2750 to 2500 cal. BC	Corded Ware Culture (I-III horizons)	Late Jevišovice Culture/Corded Ware Culture III horizon
6. 2500 to 2250 cal. BC	Bell Beaker Culture	Bell Beaker Culture
Early and Middle Bronze Age		
7. 2250 to 1950 cal. BC	Early Únětice Culture	Early Únětice Culture; Nitra Culture
8. 1950 to 1700 cal. BC	Late Únětice Culture	Věteřov-Mad'arovce Culture
9. 1700 to 1500 cal. BC	Danubian Tumulus Culture	Carpathian Tumulus Culture
Late Bronze Age		
10. 1500 to 1200 cal. BC	Knovíz Phase of Knovíz Culture; Early Lusatian Culture	Velatice Phase of Middle Danubian Urnfield Culture; Early Lusatian Culture
11. 1200 to 800 cal. BC	Štítary Phase of Knovíz Culture; Nynice Group; Silesian Phase of Lusatian Culture	Podolí Phase of Middle Danubian Urnfield Culture; Silesian Phase of Lusatian Culture
Earlier Iron Age		
12. 800 to 600 cal. BC	Bylany Culture; Platěnice Phase (C) of Lusatian Culture	Early Horákov Culture; Platěnice Phase (C) of Lusatian Culture; Vekerzug Culture
13. 600 to 375 cal. BC	Late Hallstatt/La Tène A; Stage D of Platěnice Phase	Late Horákov/La Tène A; Stage D of Platěnice Phase

Table 1.1. continued.

Epoch	*Hercynia*	*Pannonia*
Later Iron Age		
14. 375 to 175 cal. BC	Middle La Tène Culture	Middle La Tène Culture
15. 175 to cal. 33 BC	Late La Tène Culture (Turnov Type)	Late La Tène Culture (Early Púchov Culture)
Roman Iron Age		
16. 33 cal. BC to AD 175	Early Roman Iron Age	Early Roman Iron Age (Late Púchov Culture)
17. AD 175 to 400	Late Roman Iron Age	Late Roman Iron Age

The secular settlement cycle of Central Europe and the Behaviouralist hypothesis

The notion of a "settlement cycle" comprises a central construct in this work (see Chapter 2).[1] This cycle refers to the archaeologically apparent phenomenon of village-level agglomeration and dispersal during discrete (100 year) archaeologic cultural phases. Settlement agglomerations as such rarely exceed a threshold of 500 inhabitants until the Late La Tène Iron Age, a threshold which also comprises a minimal population of a sustainable co-mating group.[2] On century-level time-scales, agglomeration periods or maxima are followed by dispersed settlement archaeology phases characterised by hamlets or isolated household remains (minima). Analyses of site-specific populations suggest that settlement minimum phase local populations fall to less than 25% of their maximum phase levels, where the latter are defined as village agglomerations of 100-500.

A general Behaviouralist hypothesis accounts for this cycle on the basis of differential archaeological visibility, such visibility being dependent on the relative establishment depth of sub-surface features at flat sites where subsequent erosion may differentially erase such traces. Hypothetically, these prehistoric behaviours reflect cultural norms of domestic and storage facility construction which also change on a secular (century-level) time-scale. This hypothesis may be tested by comparing settlement patterns at tell-like

1. Bintliff 1982, 1984a, 1984b, 1984c

2. Wobst 1974, 1976

sites where there has been net accumulation of anthropogenic sediment, as well as by geo-botanical methods whose sources are independent of cultural variability. Such palynological methods measure direct human impact on vegetation. A high correlation of peaks in this proxy index of settlement intensity with maximum phases of the settlement cycle would constitute a negation of the general Behaviouralist hypothesis, given a sufficient density of sampling sites producing appropriate primary data.

Geo-botanical methodology and the Climatic hypothesis

In the geo-botanical methodology to be employed in this work, the scale of the agrarian regime as reflected in the syn-anthropic pollen response provides a rough relative measure of settlement population within the area of pollen catchment. Methods of determining the area of the pollen catchment vary at different types of sites (Chapter 3). Water transport of pollen predominates at alluvial sites, while air and human transport is more important for pollen recruitment into archaeological sediments. Not only the scale of agriculture, but also its quality may be inferred from such studies, in which specific agrarian regimes to be discerned include approximate fallows and possibilities of winter sowing after general cultigen and weed assemblages. Such agricultural regimes may also be subject to climatic forcing, whereby favourable agro-climes induce more extensive or intensive cultivation, and consequently, population growth. A test of this Climatic hypothesis will be achieved in pollen data (Chapters 6-7), once palynologically indicated oscillations in agricultural intensity are compared to Central European climate history of the later Holocene (Chapter 4). A high co-variation of cultivation peaks with favourable agro-climates constitutes an affirmation of this hypothesis given the sample size of analysed geo-botanical sites which comprise the primary data base of this work.

Individual settlement and regional polity populations

Not all variability in prehistoric settlement density may be explained by extrinsic environmental factors, however. Intrinsic social factors may also modulate the degree to which corporate settlement modes are expressed. After the geo-botany of alluvial sites in particular, human impact on the environment will reflect general population levels rather than the degree to which these populations are concentrated, and thus affords an independent line of evidence for reconstructing dia-chronic demographic change.

Confidence in the reality of the later prehistoric settlement cycle as reflected in Central European archaeology will follow after a geo-botanical negation of the Behaviouralist hypothesis. This negation will be achieved first locally at the principal alluvial pollen site in Chapter 6, and then along general lines of evidence in Chapters 13-14. The first negation provides the stimulus for a consideration of periodic variations in (modal) settlement site population required for a general negation of this hypothesis.

Thus for each of the above (Table 1.1) seventeen secular periods, a reconstruction of (modal) settlement population will be attempted after Eneolithic to Roman Iron Age settlement archaeology in Chapters 9-12, concentrating upon finds of surface huts *vs.* sub-surface features at excavated sites wherein both classes of evidence are well preserved. The significance of observed ratios lies in the robusticity of sunken features, which provide a more reliable basis for demographic reconstructions at individual settlements once such sites are chrono-spatially defined. These household reconstruction ratios are also affirmed after independent lines of evidence such as pottery sherd densities in sunken features and archaeological palynology in Chapter 13.

Once modal site populations are reconstructed on a periodic basis, scalar ranges of integrated regional populations can then be inferred after regional settlement archaeology. An increasing scale of integrated regional population (as inferred from spatial patterning of first and second order sites) limits the sustainability of more egalitarian social relations. An important demographic threshold in lies at 1,000 (see Chapter 2 below), above which political integration *via* systems of social rank are very likely to emerge.

Secondary settlement analyses will thus discern changes in later prehistoric population densities, while the limitation of farming intensity by climate and bio-geography will be inferred *via* geo-botany. With a negation of the Behaviouralist hypothesis, demographic growth cannot then be cumulative; rather, cycles of growth and contraction would characterise the Eneolithic to Roman Iron Age agricultural settlement of Central Europe. Demographic growth or decline then constitutes a measure of adaptive success, while the viability of reconstructed complex socio-political systems may then be assessed vis à vis periodic environmental limits and the exclusionary influence of alien cultural units.

2. Theoretical background and secondary methodology

Theory in this context refers to the analytical framework under which (secondary) settlement archaeological sources are to be considered in conjunction with (primary) geo-botanical data. The theoretical discussion begins with a description of the later prehistoric settlement cycle.

Empirical and theoretical themes in relationship to the later prehistoric settlement cycle

The term "settlement cycle" in this work will refer to periodic oscillations between phases of dense vs. sparse settlement remains which either reflect prehistoric demographic realities or more trivial "Behaviourist" factors which produce different kinds of settlement remains independent of demographic factors. In this chapter, the periodicity of the later prehistoric "settlement cycle" of population oscillation in Central Europe is explored according to six settlement "currencies". These periodic currencies of settlement intensity include (1) "raw" site numbers, (2) numbers of individual settlement features within investigated areas, (3) the spatial extent of individual sites or (4) site catchments, (5) the relative concentration of surface (pottery) finds and (6) the presence or absence of all site-types in ecologically circumscribed community areas. Pattern deviations of settlement growth and contraction at the micro-regional (10^{1-2} km^2) level from those collectively discernible at the macro-regional (10^{3-4} km^2) level are also examined.

Thresholds of increasing alignment with the macro-regional settlement pattern are perceived in 15, 30 and 50 km^2 (scalar) micro-regional areas. These scalar thresholds will become methodologically important once the areal pollen catchments of primary palynological sites are also assessed (see Chapter 3). The syn-anthropic pollen flora can then be used as a test of two hypotheses explaining this cycle: the (local or general) Behaviouralist and the Climatic.

The first hypothesis expresses doubt as to the reality of the settlement cycle of minimal and maximal periods, rather population is viewed as less dynamic, with settlement minima and maxima being mere products of differential archaeological visibility. The second hypothesis explains this (periodic) cycle in terms of climatic limiting factors on agriculture. Logically, a test of the Behaviouralist hypothesis must precede that of the Climatic hypothesis. A negation of the Behaviouralist hypothesis also justifies a more detailed treatment of the settlement record.

An analytical formula for measuring <u>local</u> populations of specific settlement sites is thus offered and justified. The political integrative implications of <u>regional</u> population levels for the structure of social adaptations are assessed together with "socio-political typologies" linked with demographic thresholds. A test as to the significance of land circumscription to the emergence socio-political complexity is offered, where this is minimally defined as the development of "regional polities". This "Carneiro hypothesis" is then subsumed under the concept of competetive somatic adaptation, once co-operative *vs.* competitive somatic and reproductive adaptation are defined.[1] The adaptation concept so bi-laterally defined itself constitutes the dynamic linking the twin empirical themes of natural environment and human settlement.

Because the discernment of prehistoric competetive exclusionary behaviour may depend on the identification of "alien cultural units", problems of relating actual "group ethnologies" to archaeological cultures are also addressed. Finally, hypotheses are posited as to the analytical significance of the archaeological culture to general adaptive potential, as well as comparative deductive "tests" of these hypotheses. The treatment of material culture is intended to reflect culturally imposed cognitive limits on adaptation. Comparative patterns to be assessed include the environmental correlation of cultural diffusion (Cultural hypothesis A) and the spatial scope of information flow through populations as limited by kin networks (Cultural hypothesis B).

Agricultural settlement and community areas of prehistoric farmers

What is "agricultural settlement"? Does this term refer to only settlement sites, or to entire land-use zones? After E. Neustupný, one might consider the setting for the entire range of prehistoric activity to be the settlement area of prehistoric farmers.[2] This would include living areas, fields and pasture, as well as sacred sites and cemeteries. Because only a fraction of this activity may be detectable at any one time, one must take a broad view of agricultural settlement in order to compare patterns from different periods, which in turn quite often produce very different qualities of archaeological evidence.

Although funerary evidence is only partially treated in this work due to limitations of space, it should be observed that funerary behaviour itself is structured almost entirely by cultural behavioural factors, while "living" settlement areas naturally produce a narrower range of possible physical trace "fossils" (e.g., a limited number of post *vs.* sleeper beam construction techniques and a basic dichotamy between raised and sunken storage facilities). This latter variation, although limited, can still complicate comparisons of settlement structures from

1 Carneiro 1970

2 Neustupný 1991

different periods due to factors of differential preservation. A key issue then in view of the behaviourally-dependent character of the archaeological record then is the establishment of a single measure of settlement density through time which both factors-in Behaviouralist variation and is ubiquitously encountered at settlement sites of different periods. In this work, the unit of choice will be the simple "settlement pit". Irrespective of the actual differential functions of such features, a reconstruction of ratios of such features to actual domestic occupations over a constant (25 year) basis will be attempted for later prehistory in Chapters 9-13.

Beyond the latter body of settlement evidence (in the strict sense), an assessment of the total (community) area of agricultural exploitation is problematic, although the careful application of palynology in the locus of prehistoric settlement might aid empirically in this assessment. Such studies may determine prehistoric levels of deforestation, as well as the balance of pastoral and arable agriculture and the minimum area under active cultivation. It should be noted that the community areas as defined by M. Kuna below are only inferred after presently observable natural conditions rather than primary natural historical evidence. It is hoped that this work will help to provide insights into the range of human land-use in different later prehistoric periods.

Scale of analysis and the reproducability of settlement patterns

From what geographic scale should the analysis of settlement archaeology begin? Should one expect that the developmental histories of ancient farming settlement observed across macro-regions (10^{3-4} km^2) will always correspond to those at the micro-regional (10^{1-2} km^2) level? The local (micro-regional) landscape might also be uniquely illuminating regarding the variable specific structures of dia-chronic prehistoric settlement. To begin empirically, the later prehistoric settlement archaeologies of micro-regions where such studies are best developed will serve as exemplars. Such near-complete settlement records derive from open-cast brown-coal mining areas of the Lužický and Lomský potok ("creek") basins, tributaries to the Ohře and Bílina Rivers (respectively) in Northwest Bohemia These basins represent the only "wholly excavated" settlement micro-regions in either the Czech or Slovak Republics, although micro-regions of intensive but less-complete investigation are also considered (e.g. Vinořský potok) in an empirical review of micro-regional settlement trajectories which follows.

Micro-regional settlement trajectories

The research by Z. Smrž in the basin of Lužický potok encompasses a 30 km^2 area (Figs. 1-2), in which most prehistoric settlement is concentrated within an eight km^2 area.[3] Traces of Mesolithic settlement are known from the western periphery of the basin, while the first farming settlements of the Linear Pottery Culture are relatively common in the east, comprised of six sites whose occupation continues into the period of the Late Neolithic. Typical in size and soil preference, these Neolithic sites occupy areas of up to twelve hectares on soils of a loessic substrate. After this substantial settlement, the Eneolithic as a whole produces only slight settlement traces. Early Eneolithic settlements are lacking, after which hiatus three insubstantial settlement sites of Middle Eneolithic (Řivnáč) date are established on loessic soils. Conversely, Late Eneolithic settlement evidence is entirely mortuary in character, deriving from non-loessic soils.[4] Subsequently, farmers of the Bronze Age expand settlement onto a wide variety of soil types, the find spots of this period being composed almost entirely of "settlement" (i.e. midden or storage) pits. The four (Classical) Early Bronze Age settlements are small, and comprise as a group a total of fourteen settlement pits. The scale of settlement evidence then contracts significantly during the Middle Bronze Age, when only isolated features are known at three (extensively excavated) sites.[5] Importantly, the Late Bronze Age or "Urnfield Period" witnesses an apparent expansion of settlement, with the appearance of twelve new settlement sites (with 77 features) and a cremation cemetery site. The settlement of the (loessic) eastern sector would appear to be continuous, spanning most of the long Late Bronze Age period of (ca.) 600 calendar years, while Urnfield settlements in the more sparsely populated western sector (with poorer soil substrates) would appear to be less stable in character. Within this latter sector, Smrž discerns a system of rotating settlement, whereby small farming sites would migrate up to two km after a 100 to 200 year period, sometimes returning to the same find-spot at a later date (Fig. 3). Reflecting a further minimum in the settlement cycle, Earliest Iron Age (Hallstatt C Bylany Culture, ca. 800-650 cal. BC) finds are represented by a single mortuary site (on non-loessic

3 Smrž 1987a, 1987b, 1991b and 1994

4 Neustupný and Smrž 1989

5 This total excludes terminal Early Bronze Age finds of the Reinecke Bronze Age A2/B1 Übergangshorizont. The latter term was first applied by H. J. Hundt to settlement sites in East Bavaria containing later Early Bronze Age ceramics and earlier Middle Bronze Age bronzes (dating to ca. 1500-1600 cal. BC). For the extension of this phase to Czech and Slovak material, see also Šaldová (1960), Čujanová-Jílková (1967) and Benkovsky-Pivovarová (1976).

soils) at Přezetice, where nine graves and superficial traces of settlement appear (cf. Fig. 8), although Late Hallstatt (D, ca. 650-450 cal. BC) agricultural settlement returns to the loess, where seven settlements sites are recorded.[6] Then after a Middle Iron Age hiatus, Late (La Tène) Iron Age (ca. 175 to 33 cal. BC) settlement is well-represented by thirteen huts and eight features known from two settlements (in addition to a single cremation grave).[7] Extensive settlement is reflected in finds of the Early Roman Iron Age period, whose sites produces three houses and eight other features (in addition to two cremation graves from Lužice). Finally with the Late Roman and Migration period, a pronounced decline of settlement is notable, as represented by a single hut (at Kadaň) and grave find.[8]

From the 30 km^2 basin of the Lom (ca.) 30 km to the east of Lužice, an analogous settlement sequence has also been reconstructed by J. Beneš.[9] This enclosed basin mirrors that at Lužický potok with respect to the extent and intensity of excavation (Fig. 4). The analysis at Lom differs somewhat from that of Smrž in that Beneš attempts to quantify relative "micro-continuity" through successive archaeological periods. To this end, quadrants of $(50\ m)^2$ (around small sites) and $(250\ m)^2$ (around clusters of localities or larger sites) are arbitrarily defined as boundary conditions for settlement continuity. Beginning with the (undifferentiated) Neolithic period, eleven settlement clusters are recorded. Subsequent traces of Early Eneolithic settlement do appear, albeit at only one locality one km outside the zone of substantial Neolithic occupation. Like the Lužice, the Middle Eneolithic at the Lom basin sees an increase in site numbers (3), although these also lie outside the limit of prior (Early Eneolithic) occupation. The Late Eneolithic Corded Ware Culture subsequently contributes fourteen grave sites. Once again, zones of prior agricultural settlement are largely avoided. Conversely, the (eleven) localities of the Terminal Eneolithic Bell Beaker Culture are closely tied to find spots of the Corded Ware (in 63% of cases). The Early Bronze Age sees a surge of settlement in the form of sixteen settlements and cemeteries, half of which lie within the zone of prior Bell Beaker occupation.

6 Smrž (1991b) follows the more general usage of the term "Bylany Culture" to encompass only the Hallstatt C period in this publication, while in his 1994 article, Smrž uses the term "Bylany Culture" after the sense of Koutecký (1988a and 1988b, 1993, 1994), to encompass the entire period from Hallstatt C1 until Hallstatt D1. Presumably, this abbreviates the Late Hallstatt proper to the sub-phases Hallstatt D2-3.

7 Cf. Holodňak 1987, 1991

8 Kadaň also produced pottery of the Late Roman (Eggers C-D) phase, pottery which tends to be less diagnostic than the richly decorated earlier Roman (Eggers B) wares. The Kadaň hut should be only tentatively attributable to the Migration period, given the potential standard deviation of the assays from Most (see Neustupný and Veselý 1977).

9 Beneš 1991

Like Lužický potok, the Middle Bronze Age at Lomský registers a contraction of settlement to only three localities, all of which derive from zones of prior settlement (Fig. 4).[10] Similarly with the Late Bronze Age Urnfield period, a pronounced expansion of settlement occurs, represented by thirteen sites, largely (92%) in new places. The Iron Age cultures at Lom are only broadly defined, obscuring the aforementioned dia-chronic settlement dynamic.

The work in the Lom basin invites a few comparative remarks *vis* à *vis* that at Lužice. Neolithic settlement in both areas produces evidence for fairly stable and continuous occupation by farmers in hamlets or small villages. These form micro-regional clusters of perhaps half a dozen sites in each basin. In each case, settlement traces of the Eneolithic are both scarce and significantly removed from zones of prior settlement (reflective of more mobile populations?). From this observation, one might also suspect that remains of these Eneolithic settlers may be difficult to find on account of their avoidance of larger, multi-phase settlement sites. Middle Eneolithic finds, represented by the contemporaneous Řivnáč and Globular Amphora Cultures, are more common, although these cultures produce only isolated settlement features. The two settlement histories diverge somewhat during the Early Bronze Age, when settlement in the Lom expands more rapidly than that in the Lužice basin, however both basins register a pronounced contraction of settlement during the Middle Bronze Age. The full degree of settlement expansion effected by Late Bronze Age farmers in the Lomský potok basin is difficult to compare with that at Lužický potok, because no data are provided by Beneš as to the number of features recovered from individual sites in the Lom. Comparisons of total features recovered rather than raw site counts might then be more illustrative of fluctuations in settlement densities in the Lom basin. Comparison of Iron Age settlement is also made difficult by the tendency of Beneš to obscure finer distinctions in the settlement data by lumping-together different archaeological phases into longer chronological units. Within these empirical limits, only minor variations (e.g., in the relative expansion of Early Bronze Age settlement) are observable at Lom with respect to the settlement historical pattern at Lužice on a 30 km^2 geographic scale.

The notion of settlement continuity has been defined in broader terms by M. Kuna, who defines this concept in terms of settlement within ecologically circumscribed cells.[11] From the well researched micro-region of Únětický potok basin in Central Bohemia, Kuna first delimits

10 There is a strong linkage between Middle Bronze Age settlement finds and the area excavation of multi-component sites discovered on the basis of finds from other periods.

11 Kuna 1991, Kuna and Slabina 1987

settlement zones according to factors such as distance from drainage, suitability of relief and soil type.[12] The circumscribed zones are then considered as a unity for purposes of determining settlement continuity, discontinuity, expansion and contraction. In the Únětický potok basin, Kuna thus circumscribes eleven community areas of three to five km² extent within this micro-region of some 50 km², within which Bronze Age and Late Hallstatt settlement is plotted. Accordingly, nine cells in lower drainages produce extensive settlement evidence which almost entirely falls within Kuna's ecological limits. The relative expansion and contraction of settlement can then be expressed in terms of number of cells occupied: Early Bronze Age: 7/11, Middle Bronze Age: 4/11, Late Bronze Age: 9/11 and Late Hallstatt: 9/11 (cf. Figs. 5-7). The factor of the long duration of the Late Bronze Age is mitigated in that most cells occupied in the Urnfield period include three sites dating to this period, in comparison to single settlements per cell typical for other cultural phases. Thus in terms of the occupation of ecologically circumscribed cells, the 30 km² scalar settlement trends of Middle Bronze Age minima and Late Bronze Age maxima noted at Lom and Lužice are substantiated on a 50 km² scale.

Kuna has also analysed late prehistoric settlement in the 50 km² basin of Vinořský potok in Prague-East, where settlement radii are identified on the basis of a 1.6 km catchment of individual archaeological sites. The projected area settled by Late Bronze Age farmers is the largest recorded for the entire prehistoric period, encompassing almost all of the (ca.) 24 km² of primary agricultural land available in the valley. The following Hallstatt C (Bylany Culture) period witnesses a sharp contraction to (ca.) one third the Knovíz area (cf. Lužický potok), a contraction followed by a reoccupation by Late Hallstatt farmers over a (ca.) 20 km² area (Fig. 8, cf. Fig. 46). The settlement area of the Late Hallstatt and Early La Tène then consists of cells of (ca.) four km² areas where intensive occupation is suggested by dense surface scatters of archaeologic material. Conversely, the Middle to Late La Tène period produces a more dispersed settlement pattern (Fig. 9). Finally, a <u>transformative</u> discontinuity in the mutual spatial relationships of individual settlement cells occurs during the Early Roman Period, when fewer, much larger cells of some eight km² are reconstructed (Fig. 10). These larger cells contain tight clusters of dense scatters of surface material, while their boundaries cross-cut the dendritic fluvial network, in contrast to prior prehistoric patterns. Importantly, this settlement historical pattern at a 50 km² scale exhibits a cycle of expansion and contraction which mirrors the general

12 Kuna and Slabina (1987) define these delimiting factors as all areas outside 500 m from the nearest water source, ground sloping at an incline of greater than 4.5 degrees, and all surfaces unsuitable for agriculture, such as marshes or stony ground.

Bohemian settlement tendency.

At the 15 km^2 spatial scale, the area of Kolín-South in East Bohemia as surmised by Rulf raises some questions as to potential quantum effects on the perception of settlement cycles as imposed by limited (area) sample size. Within this 15 km^2 micro-region, the history of Eneolithic settlement is particularly "out-of-phase" with that of the surrounding Český Brod macro-region. Within this Kolín micro-region then, an intensive settlement by the Early Eneolithic Baalberg Group is observed, followed by a general abandonment of settlement during the Middle Eneolithic Řivnáč and Late Eneolithic Corded Ware phases. Only with the Bell Beaker Culture does agrarian settlement recover. Conversely, within the Český Brod as a whole, the Middle Eneolithic in particular is a phase of most-intensive (Eneolithic) settlement.[13] This case gives rise to suspicions that a 15 km^2 micro-region might be subject to a significant degree of quantum variation in relative settlement density.

After these five exemplars, the "15-30-50 square kilometre (working) hypothesis" sets-out limits of potential representivity of settlement data at a micro-regional scale with respect macro-regional tendencies. At a 50 km^2 scale, a high degree of representivity *vis* à *vis* the macro-regional settlement trajectory is to be expected. At a 30 km^2 scale, minor quantitative variations in settlement rhythms from the macro-regional "norm" are to be expected; while at a 15 km^2 scale, a significant degree of potential variation is to be expected, particularly in relation to periods of lower (general) settlement density.[14]

Macro-regional settlement cycles

At a macro-regional scale, micro-regional settlement histories are largely replicated, although inter- (bio-geographic) zonal contrasts also emerge. From Rulf's survey of early agrarian settlement in Bohemia, a contraction is evident during the later Neolithic, as provinces occupied decline from 50 (Linear Pottery Culture) to 37 (Stichbandkeramik) to 15 (Late Lengyel Culture) respectively. A similar contraction of later Primary Neolithic settlement has also been noted in temperate Europe by Starling in Central Germany and Schwellnus in the intensively studied Middle Rhineland. The development of Neolithic settlement within the more-continental Pannonian zone is quite different, where the district of Znojmo (Southwest Moravia) produces

13 Cf. Rulf 1983

14 Neustupný

49 sites of the Linear Pottery Culture. Settlement intensity then increases incrementally during the later Neolithic, as represented by 53 sites of the Early Lengyel Culture.[15]

The Eneolithic produces subsequent evidence for zonal contrasts between "Pannonian" and "Hercynian" cultural boundaries. Some Eneolithic cultures of Pannonian origin would appear to be relatively contained in their Bohemian distribution: the 67 sites in 16 provinces occupied by communities of the Channelled Ware Culture are hardly in evidence west of Prague (where the Salzmünde Group continues). A general expansion in the territorial agricultural settlement is then expressed during the Middle Eneolithic of Bohemia, when 254 sites appear in 32 provinces (cf. Figs. 11-12). Notably, a low volume of Middle Eneolithic settlement is evidenced in Northwest Bohemia, where Late Eneolithic (Early) Corded Ware Culture mortuary finds are concentrated (Fig. 13 above). Finds of the evolved (Late) Corded Ware Culture are more evenly distributed in Bohemia, reflective of its progressive diffusion (Fig. 13 below).[16] Of course, a lack of settlement evidence in this strict sense limits the utility of the methodology of Rulf for the Late Eneolithic period.

A pulsatory development of settlement continues to be traced in later prehistory, where-in Bouzek has outlined periodic settlement cycles from (ca.) 2700 to 650 cal. BC in Northwest Bohemia.[17] Expressed in raw site numbers and indexed by the author after known sites established per (cal.) year, these ten phases are ascribed as follows:

1. Late Eneolithic Corded Ware Culture: 85 sites/250 years	(index = 0.34)
2. Terminal Eneolithic Bell Beaker Culture: 90 sites/250 years	(index = 0.36)
3. Earliest Bronze Age (Early) Únětice Culture: 95 sites/300 years	(index = 0.32)
4. Early Bronze Age (Late) Únětice Culture: 70 sites/200 years	(index = 0.35)
5. Middle Bronze Age Tumulus Culture: 50 sites/200 years	(index = 0.25)
6. Late Bronze Age (Early) Knovíz Culture: 75 sites/125 years	(index = 0.60)
7. Late Bronze Age (Middle) Knovíz Culture: 120 sites/125 years	(index = 0.96)
8. Late Bronze Age (Late) Knovíz Culture: 105 sites/125 years	(index = 0.84)
9. Terminal Bronze Age Štítary Culture: 100 sites/225 years	(index = 0.44)
10. Earliest Iron Age Bylany Culture: 55 sites/150 years	(index = 0.35)

15 Rulf 1979, cf. Rulf 1983, Starling 1983 and Schwellnus 1987

16 Cf. Rulf 1979 and Buchvaldek 1986b

17 Bouzek 1982

Alone, these indices are of limited significance, although once average settlement population levels are factored-in, oscillatory tendencies are greatly enhanced. This is because the Late Eneolithic, Middle Bronze Age and Earliest Iron Age finds (with index values of less than 0.35) are comprised largely of graves, with settlements being much smaller. Differential site visibility, influenced by factors such as the potential behavioural variability of later prehistoric farmers forms one basis of explanation for the later prehistoric settlement cycle.[18]

The "Behaviouralist hypothesis" and its test

The "Behaviouralist hypothesis" sets forth as its main construct the notion that variation in prehistoric behaviour, and particularly those behaviors influencing site-formation processes ("C-transforms") can have more-than-trivial effects on the establishment of archaeologically recoverable settlement features. Most crucial of these transforms is the practice of digging sub-surface features deeper than subsequent rates of erosion. Cultures which invariably produce settlement features more-shallow than 50 cm will scarcely be represented in settlement archaeology, and because the preservation of pottery relies on its burial in such contexts, not even surface traces of sites might remain from shallow deposits. As an independent variable, this C-transform can have significant-if-unpredictable effects on the relative visibility of settlement, as is proposed by Neustupný for certain phases of the Eneolithic. Further limitations on the visibility of archaeological periods is imposed by the presence or absence of diagnostic elements on pottery; for example, the settlement pottery of the Early Eneolithic is often decoratively plain and lacking in diagnostic features, making constituent settlements difficult to define. But can a general Behaviouralist hypothesis be invoked as an independent variable, dramatically and periodically affecting site visibility on a secular time-scale for the entirety of later prehistory? This hypothesis by its very nature defies positive demonstration.

Two solutions to the problem might be proposed. In respect to the archaeological record, it may be observed that the relative concentration of settlement features might also affect settlement visibility. With greater feature dispersion during a given period, a smaller number of settlement features is likely to be encountered on spatially-limited multi-cultural site excavations. Thus the discovery of features from minimal settlement phases might be a function of the extent of excavation following from site definition made on the basis of maximal phases of occupation.

18 Cf. Neustupný 1969, Schiffer 1976

This solution cannot account for a poverty of settlement traces based on a lack of diagnostic settlement pottery. A further test of this hypothesis thus lies in geo-botanical lines of evidence.

As a positivist test, independent vegetation reconstructions resulting from the application of pollen analysis might provide evidence of oscillations in the intensity of prehistoric agriculture, oscillations which are directly related to changes in prehistoric population levels. Should the results of such pollen analyses show that periods of greater (arable) agricultural intensity are quasi-random in character or relate to local events only, then the behaviouralist's hypothesis is strengthened, or at least, not negated. Should such analyses indicate that periods of greater agricultural intensity are highly correlated with settlement agglomeration phases, alternate hypotheses must be invoked to explain the perceived settlement cycle in later prehistory.

The "Climatic hypothesis" and its test

The "Climatic hypothesis" as set-forth by Bouzek proposes that cyclical variations in the intensity of prehistoric agricultural settlement can be correlated with secular climate change in such a way as to explain "recessions" in the settlement record as being dependent on lower agricultural carrying capacities (*K* capacities) as limited by cooler and wetter agro-climates, at least in the temperate Hercynian zone of Bohemia and North Moravia. It is also implied that climatic minima induce a shift in the balance of mixed agriculture in favour of its pastoral component, as stockherds are more robust than crops *vis* à *vis* cooler and wetter weather. This minimum-led agricultural adjustment encourages three positive feedback mechanisms between economic and settlement structures. Firstly in terms of site-catchment dynamics, it is more efficient for households to disperse into the community area under a mini-max regime, because of a contraction of the area under fixed cultivation and a greater dependence on more extensive pasturage.[19] Secondly in terms of demographics, dispersion is encouraged by lower general population densities ensuing from a less-optimising, satisfier economic strategy.[20] Thirdly in terms of (non-independent) behavioural variability, a greater micro-mobility of settlement discourages the construction of more substantive settlement features. Ecologically, this mini-max regime will favour a more substantive stock-herding component in the agricultural economy in order to minimise the risk of famine in the more likely event of crop failure. In this light, it is important to remember that early cultigen assemblages are dominated by emmer wheat, a taxon

19 Cf. Higgs 1975 (ed.)

20 Cf. Bouzek 1982, n.d. and Clarke 1968, Butzer 1982, n.d.

more suited to semi-arid climates than those of modern temperate Europe. This hypothesis receives historical support in the example of the Little Ice Age and its catastrophic effects on arable tracts in the Scottish uplands, tracts which are replaced by pasture.[21] Further demonstration of this hypothesis lies with contrasts observable between bio-geographic zones.

To this end, a palynological comparison of the agrarian histories of the temperate western (Hercynian) and the continental eastern (Pannonian) zones may prove informative, because the limiting factors on agriculture are principally temperature-dependent in the former zone and more precipitation-dependent in the latter. Differences of limiting factors may thus produce differential agricultural responses to contemporary climatic change. In Hercynia, co-variation of cultivation pollen maxima with warmer or drier climates will also affirm this hypothesis.

Settlement evidence and individual site population

Settlement evidence from later prehistoric Central Europe as recovered since the establishment of systematic excavations after the Second World War consists primarily of village and hamlet sites, by which is meant settlements in the range of 50-500 and 25-50 inhabitants respectively. In agglomerated phases, larger village sites are established, sometimes in inaccessible or fortified positions. Consequently, settlers disperse into hamlets and homestead isolates. Systematic estimates of prehistoric site populations are not easily extracted from the mass of settlement data in that several classes of information are required. Classes of data required include:

A. Number of (inferred) domestic units represented within excavation area: *a*
B. Number of co-residents per domestic unit (areal or inferred single family): *b*
C. Duration of occupation per domestic unit (constant @ 25 years): *td*
D. Duration of occupation of site (one century is the finest time-unit ceramically definable): *ts*
E. Inverse of the proportion of original site excavated (without "horizontal stratigraphy"): *p*
F. Constant of archaeological recovery (where partial recovery is suspected): *r*

From these factors, site population can be calculated as a function of (abp) x (td/ts/r). The parameters under which factors A through F are to be derived from settlement sites of different archaeological phases in Bohemia, Moravia and Slovakia require explanation and justification. Factor A (a), the number of recovered domestic units, cannot always be discerned directly from

21 Cf. Parry 1975

well-preserved house remains. Where erosion of domestic features is problematical, deeper sub-surface features such as storage pits can be used as a "substitute" for domiciles (no longer extant), using sub-surface to surface feature constants derived from sites where all classes of settlement evidence are well-preserved. Factor B (b), the number of inhabitants per domicile, is calculated by one of two methods. The "areal" or "Narroll's" method of Factor B calculation follows from cross-cultural comparisons of the use of living space by pre-industrial agrarian communities, set at a constant of one inhabitant per 10 m^2 of floor area.[22] It is applied where residential houses are larger than 50 m^2 (i.e., those possibly housing families larger than five individuals). In cases where domiciles are smaller 50 m^2 in floor area, it is assumed that these house a single nuclear family. This latter assumption is also made in cases where the existence of surface domiciles is indirectly presumed after the spatial patterning of deeper sub-surface settlement features (e.g., grain silos and sunken sheds). Factor C (td, 25 year constant) is presumed to equal one human generation after Neustupný. Factor D (ts) is derived along three lines of evidence. Firstly, ceramic typology and radio-carbon provide a broad idea as to the span of occupation. Secondly, relatively limited settlement evidence may be intrinsically suggestive of a single phase of occupation. Thirdly, cross-cutting stratigraphic relationships are indicative of a minimum number of settlement phases. Factor E (p), the proportion of the site excavated, can be most readily inferred at enclosed sites; although at open sites, field walking and trial trenching can provide estimates as to the true extent of prehistoric settlement. For sampling purposes, sites with a higher proportion of excavated area (40-100%) are chosen, although in many cases, "representative" sites with a much smaller proportion of excavated area (<5%) had to be employed. Factor F (r), the (fractional) constant of archaeological recovery (not always employed), is derived from evaluations of excavation reports.

Beyond the question of individual site population lies the issue of extra-local community integration, in other words, how does one determine if a given site belongs to a larger regional system? Pertinent patterns to discern to this end include the emergence of two-tiered settlement hierarchies with nodal sites containing features not encountered at lower tiers (e.g. evidence for elite residence, cult activity, technological specialisation and elaborate fortification). Specifically in the Late Bronze Age, mortuary cultic sites also appear where the scale and quality of funerary ceremonial alone demonstrates a degree of regional socio-political "interaction-integration". Finally during the later La Tène Iron Age, a rate of settlement growth is reconstructed in some

22 Narroll 1962

regions whereby a degree of inter-regional integration is suspected. This suspicion arises from an inability to account for the emergence of (inter-) regional centres on the basis of realistic natural increase in the (pre-existent) micro-regional population base.[23]

Scale of settlement and the means of community integration

The scale of prehistoric settlement, both at the local group and regional level, is directly related to the level of socio-political integration. Although such integration can be achieved through segmentary social structures such as the clan or moiety, systems of rank are conditionally more effective as a means of integrating larger populations.

Ethnography is indicative then of maximal local populations of (usually ca.) 500 to (maximally ca.) 1,500 for corporate local groups.[24] Vertical ranking, by which is meant the ascription of formal (eventually hereditary) political powers to an individual or individual lineage, can ultimately achieve a far greater scale of population integration. Minimally, ethnography indicates that populations of (ca.) 1,000 are required for the sustenance of regional polity systems. Degrees of correlation between individual community scale and the number of established (elective or hereditary) political offices in pre-industrial (agrarian) societies have also been established by Ember, statistically significant to $r = 0.80$ (see Table 2.1 below).[25] An inverse logo-rhythmic rather than linear relationship exists between these factors, a product perhaps of qualitative changes in the scope of political office with larger political units.

Table 2.1. Populations of maximal individual settlements and political complexity

Population of largest individual settlement	*No. of political offices*
50-100	2-4
100-500	2-7
500-1,000	4-12
1,000-5,000	4-12

23 Cf. Hassan 1981, Hodder and Orton 1976

24 Kosse 1990, 1994, cf. Earle and Johnson 1987, Ember 1963

25 Ember 1963

25 Feinman and Neitzel 1984

Demography, levels of socio-political integration and systems of social ranking

Linkages between critical local (500) and regional (1,000) population thresholds, levels of socio-political integration and systems of social rank are now explored in anthropologic terms. Beginning with Steward's Theory of Social Change, environmental limiting factors are described as determinative between *K* capacities, population levels and levels of socio-political integration in situations ranging from family to band to tribe. Primary nuclear families occur only among groups in regions of low *K* capacities such as the Western Shoshone in the arid Great Basin. Larger kin groups are assembled into patri- and composite-bands which inhabit less marginal territories, and usually consist of 25-50 individuals per band. Circumstances of still greater economic productivity then gives rise to the "tribe". The latter term is initially cognitive rather than political, and refers to a loosely-organised population of several hundred to several thousand comprised of local groups of less than 500 individuals.

The latter demographic limit also lies at a crucial psycho-physiological threshold of the long-term memory, determining in turn the maximal group size (ca. 500) with which a single individual can partake on egalitarian terms, in other words, without ascribed and formally symbolised ranking. These latter symbolic expressions are pivotal in the artificial construction of human relations in complex society. Natural selection has probably played a role in the establishment of this (500) egalitarian limit, as this is also the projected upper demographic limit of a minimal mating group of Middle to Upper Palaeolithic hunter-gatherers.[26]

Attempts to better define "the tribe" follow after Service and Sahlins. Service's Primitive Social Organization sets forth an influential (if semi-arbitrary) scheme distinguishing between tribes led by "Big-men" (leading self-made men serving a variety of socio-economic roles), and those led by "chiefs" (of similar powers, albeit with hereditary role ascription and a certain ritual distance).[27] Sahlins' Tribesmen also draws attention to a great variability of tribal formats, in which both simple and linear segmentary systems are recognised. The former consists of somewhat uncohesive local groups bound by notions of common identity, while the latter tribal population reacts as a cohesive body within the context of inter-tribal warfare. In such linear tribes, degrees of kin-relationship are strictly reckoned-with when the defense of any one tribal segment is in question. Close kin fight with close kin, and all fight together when opposing

26 Wobst 1974

27 Service 1962

alien tribes.[28] The importance of the clan in all tribal societies is emphasised, clans being aggregates of cognate lineages. Notably, local groups are often comprised of multiple clans.

On the other hand, tribes regionally integrated by "chiefs" are exclusively linear (in ethno-history), with a lesser or greater degree of ranking between lineages. In so-called "simple chiefdoms", but a single ruling lineage is recognised, which by necessity of a smaller (1,000+) regional population must inter-marry with lower ranking clans, unless stronger inter-regional ties with other chiefly lineages are realised through (ritualised) exchanges.[29] Sometimes, inter-clan boundaries are established in a conical ranking of lineages below the chiefly line, establishing a pan-tribal pecking-order. Larger chiefdoms can attain a greater distance between chief and commoner through the establishment of caste boundaries between lineages. Once such a hierarchy of lineages is established, a major pre-condition for class society is entrained.

In The Evolution of Political Society, Fried criticises the increasing elaboration of these social typological schemes. The "big divide" lay with the mode of social power and the means by which it is acquired: personal achievement *vs.* hereditary ascription.[30] This divide between the two modes of power might occur at scalar thresholds over-lapped on the one hand by powerful Bigmen, and on the other by simple chiefs. As implied by Johnson and Earle's Evolution of Human Societies, this demographic threshold lies at (ca.) 1,000 regional inhabitants.[31] The significance of this threshold lies in the limited psycho-physiological ability of human beings to inter-act (without formal rules and symbols of rank) with integrated populations of more than (ca.) 500. By means of segmentary societies (e.g. moieties), higher population levels might be integrated without formal ranking; however, the resulting lack of societal cohesion in the face of inter-community competition (warfare) might in time give rise to more-cohesive, more-vertical modes of control (ranking). In ranked societies, regional populations might exceed 1,000, although the reduction of village autonomy may encourage a local fissioning at lower (150 inhabitant) population levels through the removal of local political officers usurped by the regional power. Thus macro-village agglomerations of up to 500 inhabitants might be more common among segmentary societies than those with established vertical ranks.

The manner in which this "1,000-inhabitant regional threshold" is reached in historical societies is not specified, and although demographic growth might most naturally be invoked, it

28 Cf. Sahlins 1961, 1968

29 Malinowski 1922

30 Fried 1967

31 Johnson and Earle 1987, Forge 1972

is important to remember that the Nguni Zulu chiefdom was established by conquest alone. This polity grows from a local group with 50 warriors in 1775 to a territory encompassing 30 tribes under Dingiswayo within only 25 years. Such a rapid rate of conquest and its consequent scope of socio-political integration was achieved largely by segmentary means, for example through the establishment of warrior age-grades which cross-cut prior tribal divisions.[32] Notably, it has been proposed that only at the limits of expansion are the warrior roles of chiefs supplanted by those of priests, a substitution of the means of social reification after polities are established by warfare. Such wars of conquest appear to be the primary means of chiefdom expansion, with modest complex chiefdoms in Polynesia of (ca.) 5,000 inhabitants in places coalescing into larger polities of 10,000 or more, for example at Tahiti.[33]

By applying the above (150, 500 and 1000) population thresholds to local and micro-regional settlement archaeology, a comparative reconstruction of potential population thresholds of socio-political transformation during later prehistory will be made on a secular periodic basis in both the Hercynian and Pannonian bio-geographic zones (see Chapters 9-12).

Social evolution: the materialist test

The development of social complexity has sometimes been attributed primarily to materialistic factors, for example the development of key technologies and the relationship between the circumscription of agricultural land consequent to growing populations. A curt dismissal of technology and its social management as a primary motor in the development of social complexity, following from the "Neolithic" technological levels observable in the New World civilisation, has shed some doubt as to whether-or-not technology plays a necessary role.[34] Following Boserup's thesis on the development of more-intensive modes of agriculture in response to population pressure in Sub-Saharan Africa, Carneiro further developed a thesis of social evolution based on evolutionary biology, namely that of "competitive exclusion".[35] Respecting the competitive exclusionary principle, he states that should two organisms compete for the same habitat, "one will ultimately prevail". This simplistic formulation ignores more

32 Service 1975

33 Carneiro 1990, 1970

34 Carneiro 1974

35 Boserup 1965, Carneiro 1978, cf. Mann 1986

complex relationships expressed in matrix format by Lotka-Volterra.[36] The "political extension" of the competetive exclusionary principle focuses on the nodal importance of circumscribed agricultural land, whereby subsequent social competition over land ultimately leads to the formation of larger political units, primarily through the act of conquest. Here the absolute limiting factor of material agricultural resources is invoked as a primary mechanism which sets forth humanity on its course towards complex society.

In relationship to the potential influence of land circumscription to social evolution in late prehistory, the author hopes to reconstruct the ancient agricultural regime with respect to the degree of land-clearance and intensity of cultivation. Should positive correlations arise between periods of intensive land-use and those of population agglomeration to a degree indicative of social complexity, an affirmation of the Carneiro hypothesis might be effected, depending respectively on two positive (A and B) or one (A or B) negative conditions:

A. A high degree (50+%) of land clearance on prime farmland and short fallow (<4 years) on cleared land (cf. definition of "Level 1" cultivation in Chapter 14)
B. Reconstructed settlement systems of a greater scale than those maintainable by local groups

Condition A will be tested through primary palynological analysis of select field samples from alluvial and archaeological sites. Condition B will be tested through a periodic review of (secondary) settlement archaeology, 3500 cal. BC to AD 400. More problematical are cases where high population densities are not linked with the development of social complexity, a case ethnographically observable in the Enga, a war-prone New Guinean society which achieves population densities of 200+ persons per km^2, and yet is subdivided into tiny hamlets whose integrated populations remain well below the noted 500 inhabitant threshold. More-over, when considering the inter-regional socio-political integration achieved by the five Iroquois tribes of New York (each of ca. 1,000 individuals only) within a relatively un-circumscribed woodland environment, the ethnographic data base alone suffices to arouse suspicion as to whether factors beyond agricultural land circumspection lie behind the development of regional polities.[37]

36 Lotka 1956

37 Cf. Fenton 1978. Wray (1991) also reconstructs a pattern of dual settlement for the Seneca (Iroquois) during the Late Prehistoric and Early Contact periods. The Seneca appear to have inhabited only two villages within a wide expanse of North-Central New York at any one time. Two typical settlements (Tram and Cameron) would appear to have "upped-stakes" every 25 years with the exhaustion of local agricultural land (swidden is necessary on the relatively poor acid soils of this region). Although land shortage was never a nodal concern for the five tribes of the Iroquois, archaeology and ethno-history attest to significant levels of warfare and inter-regional political integration (cf. Tuck 1971, 1978).

Limitations in the understanding of cultural ecology

Environmental archaeology has often followed a rather limited definition of prehistoric "adaptation" with respect its almost exclusive focus on subsistence (in ecology, this is called "somatic" adaptation). Adaptation as such, rather than being seen as in need of being demonstrated, is presumed as a human constant independent of culture.[38] Adaptation is also assumed to be uniform within uniform environments, and the task is to ask "how did they adapt?", not "did they adapt?". Perhaps reacting to this "Higgsian" emphasis, Butzer's Archaeology as human ecology also sets forth principles defining the cognitive limitations of adaptation, including information theory and "cultural-psychological filters". These cognitive limits modulate the perception of the environment and serve to channel somatic adaptation.[39]

Co-operative and competetive somatic vs. reproductive adaptation

Further limitations of the archaeological understanding of adaptation become apparent when considering the basic principles of the body of theory from which these ideas derive: population biology. In short, the latter body of theory explains adaptive fitness in terms of differential reproductive success, achieved bilaterally through optimal foraging and mating strategies. Should we ultimately assign the archaeological concern with subsistence to somatic adaptation as reflected in optimal foraging (farming) theory, the complex question of mating theory remains under-developed, mating theory being typically assigned to the separate analytical category of "society", and thus quite divorced from its potentially determinative significance in ancient cultural ecology.[40] Preferably, bilateral (i.e., somatic and reproductive) regularities observed in population biology should be invoked to help explain systemic human behaviour.

Respecting somatic concerns then, adaptations most often take the form of optimal subsistence strategies (to be explored in detail in Chapter 8), although where these concerns involve direct (material) competition, adaptive strategies might also include raiding or warfare. Carneiro's political extension of the principle of competitive exclusion is one such example.

Respecting reproductive adaptation, two modes may be envisioned: co-operative and

38 Cf. Higgs 1975 (ed.)

39 Butzer 1982, cf. Rappaport 1978

40 Wobst (1974, 1976) provides an exception to this rule which has rarely been broken since.

competitive. Co-operative reproductive adaptation is by far the most important of the two modes, with the minimal mating pools calculated by Wobst being an optimal product of minimising the variance of mating distance between ancient hunters through the reduction of group-counter-selective behaviour such as incest (which serves to increase the variance of mating distance).[41] It would appear that where subsistence concerns are not a limiting factor, human populations will approach concentrations equal to the minimum mating-pool of (ca.) 475 individuals (note once again the potential consequences of this threshold on scalar limits of intimate human inter-action). Where *K* capacities are lowered, with correspondingly lower population densities, more extensive mating systems will be encountered, often with more-complex rules of marriage as the "value" of individual mates increases. This relative social complexity serves the total mating pool by decreasing the variance of mating distance.[42] Where ranking enhances the potential reproductive "value" of individual mates in complex society, elaborate rules of mating may also emerge in response to effective lower population densities of high-ranking individuals subsisting off systemic surplus. Such "vertically-transposed" mating pools of higher-ranking individuals may develop distinctive ranked-group-oriented behaviours.

Although the very fact of near-equal human sex ratios strongly implies that polygamy has always been a secondary human behavioural trait, competitive reproductive behaviour has also been invoked as a cause for warfare amongst the Orinoco Yanomamo. Chagnon's proposal that "killers" or "unokai" of that tribe achieve greater differential reproductive success need not have extrapolative implications, not in the least because this case represents a recently de-stabilised tribal grouping whose members have certainly not achieved an "Evolutionary Stable Strategy" (i.e., the composition of the Unokai aspect of the population cannot be maintained as proposed by Chagnon over inter-generational time-scales). By comparing the indicated proportion of "unokai" to their inferred differential reproductive success, the non-equilibrium status of this social state can also be quantitatively demonstrated.[43]

However, the notion that the expression of individual prowess may enhance social status does have an anecdotal basis in ethnography. For example, amongst the Angami Naga of Assam, the status of males depends largely on their abilities in hunting and raiding, females stating that to

41 Wobst 1974. Levi-Strauss (1949) argues that marital prohibitions on incest are not linked with awareness of its negative genetic side-effects. Cross-cousin marriage, a common if marginally-incestuous practice, emerges as a means towards controlling the inter-generational flow of property.

42 Cf. Birdsell (1953) and Yengoyan (1968) who apply these ideas to hunter-gatherer populations in Australia. There are no *a priori* grounds to dismiss their application to agrarian communities.

43 Chagnon 1990, Albert 1989; cf. esp. Chagnon 1989 and Maynard-Smith and Price 1973.

marry a man without such status would bring "rebuke and shame".[44] Also in Melanesian Big-man societies, acquisition of personal status through the slaying of a foe is the primary reason cited for "raiding" amongst the Inseg of Northwest Luzon.[45] The propinquity of such "aggressively ambitious individuals" in "Big-man (or pre-linear tribal) society" thus raises the possibility that such behaviour might represent a minority trait in a "<u>Mixed</u> Evolutionary Stable Strategy" matrix, a trait which is <u>favoured</u> in the former mode of socio-political integration.[46]

Analytical archaeologic framework

The adaptations of later prehistoric agrarian communities of the Czech and Slovak Republics are to be analysed under an systemic analytical frame-work of population dynamics, social organisation, technology, material culture and cognition. The significance of material culture and cognition to this analysis is difficult to define, although the adaptive significance cultural variation, as well as a concept of the use of the archaeological culture as an analytical unit of adaptation will be considered.

The use of the abstract term "culture" within the context of this work follows the analytical method of Clarke (as modified by Klejn). Phenomenally, the archaeologist encounters the abstract "culture" as an assemblage of artifacts, the abstract "type" as the individual artifact and the abstract "attribute" as a property found on the individual artifact. The significance of these abstract terms is not *a priori*, so that that repeated perception of closed assemblages is necessary for recognition and definition. The analytical abstractions referred to as "culture groups" and "techno-complexes" are inferred on the basis of lower thresholds of cultural similarity and mere technological similarity (respectively) as expressed in a multiplicity of assemblages.[47]

Group ethnology and ethno-archaeology

The significance of material culture to human culture as defined by ethnicity has been a focus of study, although the body of "ethno-archaeological" data is limited. None-the-less, the

44 Hutton 1969

45 Keesing and Keesing 1934

46 For a discussion of cognitively-led , multi-modal adaptive equilibria of matrical behavioural outcomes from natural selection in neurologically complex populations, see Maynard-Smith and Price 1973 (cf. also Dunbar 1991).

47 Clarke 1968, Klejn 1982

potential ethnic significance of cultural divisions may be important for the giving of meaning to the identification of prehistoric and proto-historic "alien cultural units". Different levels of socio-economic or political integration (as well as kinship systems) may also produce different patterns of spatial correlation between ethnological entities and ethno-material culture.

Within the context of foraging societies, mixed findings amongst the (patri-band) Kalahari San suggest that some symbolic artifacts (men's projectile points) have indicative value with respect to (dialectic tribal) ethnicity, while most other artifact types (esp. "feminine" artifacts) do not.[48] Amongst pastoral mixed agriculturalists in East Africa, such "masculine" symbolic artifacts have different indicative values with respect to the tribe which uses them. For example, Turkana-style spear points amongst the Turkana of the Rift Valley are bearers of the symbolic message "I am Turkana", while as these are adopted by the adjacent Lokop, they indicate "I am age-grade X".[49] Amongst the Lokop, systems of social organisation based-on male age-grades serve to make the cohort the essential locus of conscious social identification.

Subsistence divisions between pastoral and agricultural segments of a singular tribe can also give rise to differences in material culture, as is suggested with respect to the Pokot of the Barango District in East Africa. Here the pastoral aspects of the Pokot tribe imitate the material forms of the Turkana, forms which are alien to the agricultural aspects of the Pokot. Despite their material cultural influence, the Turkana engage in almost no trade with the pastoral Pokot. In this case, techno-complex convergence has over-ridden social affiliation in the ethnological association of material culture. Conversely, within the Barango district itself, intensive trade (as opposed to socially-embedded exchange) between the matri-local Tugen and Njemps results in little mutual material cultural influence.[50] Amongst these latter agriculturalists, a lack of mate transfer parallels a lack of cultural information transfer. Analogously within each tribe, male-associated artifacts display a greater spatial range of uniformity, perhaps because of male-transfer as imposed by post-marital residence rules. The importance of kinship linkages for material cultural convergence in tribal societies is thus affirmed in the Barango study.[51]

Most important to the material cultural definition of group ethnography are the ethnological

48 Weissner 1983, 1984

49 Larick 1991

50 Cf. Johnson and Earle 1987 and Hodder 1977

51 Cf. Hodder and Orton 1976. Formal mechanisms of inter-regional exchange of symbolic artifacts first appear in highly developed Big-man societies such as the Kwakuitl (Johnson and Earle 1987). These mechanisms are more typical amongst so-called "simple chiefdoms", such as the Kula ring of the Trobriand Islands (Malinowski 1922).

catalogs of the California Indians of Kroeber. The latter form a major basis for Clarke's analysis relating archaeological cultures to ethnographic entities and establish a 65-95% range of shared elements which forms a base-line defining tribal and archaeological cultures. Problems of this method emerge in the difficulty of comparing like-with-like, in that the elements of group ethnology description are necessarily different from the material elements (attributes and types) used to establish "similarity thresholds" which define an archaeological culture.[52] Clarke is also too optimistic in his prediction that up to 15% of original group ethnological material will be archaeologically observable under optimal conditions (a preservation rate of 5-10% might be more realistic). Thus when comparing the regional divisions which comprise the Late Prehistoric archaeology of California with its ethnographic zones, archaeological zones are considerably larger in area. Ecological zones are also closely defined by the "archaeological culture zones", facts suggesting that culture groups-cum-techno-complexes are being defined. The notion that non-subsistence aspects of material culture may also reflect culturally limited somatic adaptation (at bio-geographic boundaries) is thus supported. Respecting the ethnicity of archaeological cultures, territories encompassed by the latter might represent many tribes. However, inter-cultural transitional zones might also represent fluctuating tribal boundaries.

With the establishment of higher orders of socio-political integration, there is reason to ascribe the exchange of information and archaeological culture formation to vectors other than the segmentary reciprocity of peoples converging on a singular cultural adaptation. However, in the simple tribal context, convergence and divergence of bilateral adaptation is represented in the convergence and divergence of material culture through shared subsistence strategies (mini-max or optimising) and shared kin networks (representing co-mating populations). Given the equivocal indicative value of the material culture *vis à vis* ethnicity, "lower" archaeological phenomenal levels (i.e., in specific artifact or property composition rather than the definition of archaeological cultures) might be more indicative of "true" tribal boundaries. Where cultural boundaries coincide with bio-geographic ones, culture-groups thus might also behave like techno-complexes. Problematically, convergent or divergent culture histories are sometimes obscured by arbitrary regional cultural designations (usually at political boundaries) and a naive application of a "culture brick" model where polythetic sets of artifact assemblages exist.

52 Clarke 1968

Cultural cognition and its "adaptive filter"

In terms of adaptation, the way prehistoric people think about their environment is at least as important as how they eat and sleep in it. With regards to human thought about nature in prehistory, we may infer on the basis of examples from pre-industrial society that this was intimately bound-up in magic and religion, the abstraction between humanity and nature being a later operative one and one most common in industrial society.[53]

Systems of thought channel potentially adaptive behaviour.[54] Not all behaviour need be adaptive, nor be adaptive in the manner as intended by a given population. Thus cult might serve to engender adaptive group coordinated action, as suggested by the invocation of ancestor worship in the *rumbin* ritual of the Tsembaga Maring. This ritual encourages individual sacrifice (pork for allied clans) in a political economy of periodic inter-clan warfare in highland New Guinea.[55]

The emergence of such "group selective" behaviours implies that an "egotistical" view of adaptation provides an incomplete frame of reference. How one defines "the group" also changes with social rank. As true ranking emerges, behaviour determined by and favouring high-ranking groups may not impart the same benefit on lower orders of the populace.[56] Furthermore, vertical systems of information exchange which are modeled as emergent adaptive qualities of more-complex societies need not produce generally adaptive information. Unless the socio-politcal system is subjected to severe stress, the acceptance of new varieties of information is contingent only upon the perception of their adaptive quality from the viewpoint of the system decision-makers. Thus, the adeptness of more-complex societies at processing greater quantities of information need not feed-back into higher levels of mean (societal) fitness.[57]

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53 Hallpike 1979

54 Cf. White 1967

55 Peoples 1982

56 This assertion is supported by the relatively equivalent rate of population growth to be observed historically in both simple and complex agrarian societies of ca.0.1% *per annum* (Hassan 1981). Health levels within the latter societies would in fact appear to be lower, for the lower orders at least (Johnson and Earle 1987).

57 Cf. Rappaport 1978 and Deiner 1980

The environmental system and comparative propositions of cultural adaptation

The environmental context of cultural adaptation takes many forms. Environment is to be analysed within this work in terms of five sub-systems after Clarke and Butzer:[58]

A. Flora, to be analysed on the basis of primary (palynological) and secondary sources.
B. Fauna, to be analysed on the basis of secondary (archaeological) sources.
C. Geology, to be analysed on the basis of primary and secondary (morphological) sources.
D. Climate, to be analysed on the basis of secondary and primary (palynological) sources.
E. Alien cultures, to be analysed on the basis of secondary (archaeological) sources

The history of all five sub-systems will traced on a century-level time-scale on a comparative basis between the Hercynian and Pannonian zones. Natural historical evidence thus assembled will then be compared to cultural history under two hypotheses in order to infer the extent to which the archaeological culture itself might be regarded as an adaptive system. It is explicitly assumed that individuals are tied to kin-groups in an embedded economy which serves to communicate culture traits. These cultural hypotheses are formulated as follows:

A. Differential cultural adaptation to distinctive environmental conditions in Hercynia *vs.* Pannonia will result in (in-phase) modifications of cultural distributions. Given differences in factors limiting the growing season within each bio-geographic region, climatic changes resulting in shorter growing seasons initially "favour" the cultures of temperate Hercynia (mini-max-adapted), while those of continental Pannonia (optimiser-adapted) are initially favoured by optimal agro-climates. This differential adaptation will be expressed in alternating directions of cultural influence as populations "infiltrate" in either direction, from the north and west during minima, and from the south and east during maxima.

B. In the absence of higher order socio-political integration, spatially-restrictive cultural zones will develop in tandem with higher population densities, reflective of more restrictive systems of population inter-action. Under these same conditions, spatially-expansive culture zones will develop in tandem with lower population densities and a reduced K capacity of adaptive niches.

58 Clarke 1968, Butzer 1982

Although ultimately, it is the individual who adapts or fails to adapt, the degree to which archaeological cultures contain truly inter-active populations will modulate the degree to which these can also be considered as analytical units of adaptation. With ecological or social crises, rapid disintegration of old and reformation of new archaeological cultures might reflect the reorientation of human populations and their networks of information exchange. During such transformational phases, material cultural trait distributions may become more polythetic in character against background conditions of enhanced rates of cultural information rejection, equivocation and addition of new variety.

Over time, new varieties of generally adaptive culture traits will accrue, serving to stabilise and increase environmental-demographic K capacities. These developments also (positively or negatively) feed-back into environmental modification, with the anthropogenic transformation of vegetation and soil cover, sometimes reducing environmental-demographic K capacities. These transformations of the environment are to be reconstructed primarily by means of a geo-botanical methodology.

3. Primary methodology

Primary methodology refers to the framework under which geo-botanical data collection, analysis and interpretation has taken place towards the reconstruction of prehistoric environment and human impact on that environment. Primary pollen studies derive from alluvial cores and archaeological sites containing suitable deposits. Towards interpretation of these primary pollen data, analog studies are also reviewed. Such pollen analog studies address the problems of assessing anthropogenic indicators in pollen diagrams (syn-anthropic flora), the determination of the areal indicative value of pollen spectra and the taphonomy of alluvial palynological situations. Laboratory techniques and synthetic methodological aims are furthermore addressed.

Introduction

In reconstructing ancient agrarian ecology in Central Europe, the author has collected pollen samples from lowland settlement zones of Bohemia, Moravia and Slovakia. Because these zones lie beyond the Weichselian glaciation, consequent unfavourable soil conditions for pollen preservation necessitated an informed sample collection strategy.

Geo-botanical analyses will attempt to discern of human impact on vegetation through the identification anthropogenic indicator species or syn-anthropic pollen types from sites in the locus of prehistoric agricultural settlement. An increasing intensity of human impact is reflected in the (sub-climax) palynological progression from primary to secondary woodland and a variety of herbaceous taxa. Amongst the non-tree pollen, increasing human impact may be discerned in the (semi-arbitrary) divisions of pasture, culture-steppe or fallow, cultivation weeds and cultigens *per se*.

Methods of reconstructing steppe development and local soil micro-climates at sites in the Northern Carpathian Basin *via* pollen-climatic response surfaces are also justified. Limitations of the latter method lie in the difficulty of differentiating human impact from climatic forcing as factors affecting the development of Pannonian steppe vegetation.

After pollen analog studies, it is inferred that alluvial sites will represent vegetation primarily within the watershed preceding the sampling site, in addition to a secondary air-borne pollen recruitment component. A more local environment is usually reflected in the pollen taphonomics of archaeological sites. Although air transport is important to pollen taphonomy in archaeological situations, the physical transport of pollen into sediments (as variably effected by human and animal activity) should also be considered as a possible taphonomic vector when interpreting archaeological pollen spectra.

It is methodologically important to assess the land area represented by a given pollen spectrum when using anthropogenic indicator species in the reconstruction of ancient agricultural practice. This is because most syn-anthropic pollen types have poor aerodynamic characteristics, and thus, air transport of primary cultigen and secondary weed pollen will be marginal beyond the immediate locus (ca. 0.5 km radius) of the sampling site (unless these consist of aerodynamic types).

Importantly, alluvial (and lacustrine) sites might register agricultural pollen from beyond this air transport limit, as far as the reach of watersheds which can effect the hydrological transport of pollen grains onto an alluvial accretion surface (or lake bottom). In larger fluvio-lacustrine systems, hydrological pollen recruitment might thus attain a macro-regional scope. The fact that flood-loams (a depositional product of agricultural erosion) comprise a major part of alluvial accretion sediment also gives rise to an expectation that syn-anthropic flora will be favoured in representation in alluvial pollen diagrams *vis a vis* those from lakes or mires.

Additionally, water transport may modulate the degree to which (floating) air-sack (conifer), or “saccate” pollen is represented in alluvial accretion sediments. Under this hypothesis, differential saccate taphonomy is largely a factor of the depth relation between the local water table and the alluvial accretion surface, in which low water encourages and high water discourages the entrapment of (floating) saccate pollen into sediment. This “alluvial extension of the Neves effect” (see below) may be most significant on planar alluvial accretion surfaces of low-order drainages.

Palaeo-ethnobotany in Central Europe

Palaeo-ethnobotany, or the study of plants used by ancient peoples, employs a wide variety of scientific techniques. A primary means of determining the nature of human use of the floral environment are macro-"sub-fossil" remains, ranging from carbonised seeds or wood to the wider range of material preserved in water-logged environments or as ceramic impressions.[1] Palynology, the study of "dispersed" (cf. παλυνειν) micro-sub-fossils such as pollen grains, only partially intersects this discipline.

Macro-botanical finds of carbonised remains (and ceramic impressions) reflecting upon ancient agriculture in Central Europe will be reviewed in detail on a periodic basis in Chapters 8-12, although in general, it may be said that Neolithic cultivation is dominated by emmer wheat and strains of hulled and naked barley. Barley then becomes more important in the cooler Eneolithic, perhaps because of its superior edaphic qualities *vis a vis* the largely sub-optimal agro-climates of the period. During the Bronze Age, a wider variety of formal (separated) cultigens appears, including bread wheat in the (Pannonian) Early Bronze Age, millet in the Middle to Late Bronze Age and spelt wheat and horse bean in the Urnfield period, reflecting adaptations to a range of pedologic, climatic and demographic conditions. Nitrogen-fixing pulses then rise to prominence, first in the Early Iron Age, while oats (edaphically suited to "Sub-Atlantic" climates) first appear as a crop in the La Tène Iron Age. Rye, an indicator of winter cultivation, becomes a significant cultigen in the Roman Iron Age and a dominant one in the Early Middle Ages.

The ethno-botanical history of the para-cultural, syn-anthropic weed vegetation in Central Europe as reflected in macro-sub-fossil evidence has also been traced by Willerding (and calibrated by the author).[2] Beginning with a group of eight archaeophytes (relicts of the Late Glacial steppe), farmers of the Neolithic and Eneolithic expand the range of syn-anthropic taxa to 120 species in a period of 3200 (cal.) years, or a rate of increase of 2.8 species/century. During the 1200 (cal.) years assigned to the Bronze Age, the range of syn-anthropic vegetation increases at a somewhat faster rate, from 120 to 157 species, or 3.2 species/century. Then during the Pre-Roman and Roman Iron Ages, the syn-anthropic flora expands to 253 species, or an addition of 6.9 and 10.3 species/century respectively. This increased rate of influx may reflect later agricultural practices such as the winter-sowing of crops, the introduction of new crops and the development and/or use of iron agricultural tools. These agrarian practices also can be palynologically discerned in the changing composition of weed and cultivation flora.

1 Cf. Renfrew 1973

2 Willerding 1986

Empirical limits of pollen studies

The relationship between ancient farming settlement and natural environment can be comprehensively revealed by means of palynology. With the mechanics of pollen deposition in alluvial situations being independent of culture, and with the aid of pollen analogs, ancient farming ecology and the quality and scale of the cultural modification of the natural environment can be reconstructed after uniformitarian principles. Inferring patterns of ancient land-use might then be possible after observing cultigen and weed pollen assemblages. Empirical limits of such analyses include problems of specific pollen taxonomy, the ambiguous land-use indicative values of certain pollen types and inferential limits in the reconstruction of the area of pollen catchment.

Syn-anthropic pollen taxonomy and inferring patterns of land-use

Among the pollen taxa comprising the primary cultigens, *Secale cerealia* (rye) is the easiest to identify (on the basis of shape and exine surface characteristics), while the impossibility of differentiating *Panicum* (millet) as a cultigen follows from the fact that the mean size range of its pollen grains falls below generally recognised boundary (40 μ) for the identification the general cereal pollen type. Under optimal conditions of preservation and observation, a generic level of taxonomy may be achieved between *Triticum* (wheat) and *Hordeum* (barley), while the differentiation of *Avena* (oats) from *Triticum* is quite problematic. It is also probable that very large (>60 μ) grains of the *Triticum*-type represent more modern strains such as *T. aestivum* (bread wheat).

Amongst the para-cultural pollen flora, higher values of more disturbance-resistant herbaceous taxa may be indicative of the development of more intensive agrarian regimes. Technological aspects of such regimes may involve the adoption of the traction-ard, iron tools and (later) the mould-board plough.[3] Flora favoured under an intensive agricultural regime enjoy an annual life-cycle or are capable of extensive vegetative (re-) growth at root level, for example *Polygonum convolvulus*. Later in prehistory, new weeds of cultivation rise to prominence in Central Europe which are favoured by Sub-Atlantic climates with cooler summers (but <u>not</u> colder winters). Many of these taxa are also more

3 Cf. Behre 1981

specifically diagnostic, for example *Centaurea cyanus* and *Agrostemma cf. githago*.[4] The latter para-cultural taxa may be indicative of regimes of winter sowing, especially where these occur with rye (or barley) pollen.

Iron sickles (rather than scythes) also enable the establishment of hay meadows whose pastoral ecology will vary from that of rough grazing. Hay-cutting thus favours flora flowering after the period of the hay harvest (these are often composites), while rough grazing favours a more ruderal vegetation (these are often docks and plantains).

Ruderal or foot-path communities are universally favoured in proximity to human settlement. Pollen types belonging to the group also form in agricultural wastes, and are subsequently placed (semi-arbitrarily) into pastoral and fallow divisions according to the methodology of K.-E. Behre.[5] More conformative with continental climes is the culture-steppe division. This division recognises dry-land herbaceous vegetation as distinct from wet pasture. The culture-steppe also includes potential halophytes, plants which are capable of exerting great hydrostatic pressures on a salty soil matrix.

Climatic response surface assessment of soil moisture levels and steppic development

From sites in the Pannonian bio-geographic zone, agro-climatic reconstructions of the local floral-soil interface will be made on the basis of response surfaces of pollen taxa, as derived from (pristine) North America climate analog sites. This data of COHMAP link relative response values of pollen taxa with specific precipitation and temperature conditions.[6] In this context, a "prairie forb" component of *Artemisia*, *Chenopodiaceae*, *Compositae tub.* and *Compositae lig.* reflects the development of the steppe. Response surfaces of these taxa are then employed (with the support of other proxy evidence) in order to reconstruct effective soil moisture conditions which have a bearing on the question of Pannonian steppe development. Because steppe expansion may follow from either warmer or drier soil micro-climates, oxygen isotope data from later Holocene South Polish tufas will be employed to define palaeo-temperatures. Changing soil moisture conditions will then be assessed after primary pollen data in Pannonia.

4 Cf. Lange 1974

5 Behre 1981

6 Bartlein et al. 1986, cf. Pazdur et al. 1988, cf. Willis et al. 1998

General principles of pollen recruitment

Factors determining the recruitment of pollen into bio-stratigraphic (and archaeologic) sediments have been the subject of study since the seminal work by Tauber, work discrediting the notion of a general "pollen rain". Tauber presents in its place is a multi-component model of pollen recruitment into bio-stratigraphic sediments, by virtue of which air-borne pollen was divided into components of increasingly regional significance. These components include the pollen of floor vegetation in the relative stillness of the forest (trunk-space component), the extra-local pollen carried through and over the forest canopy (the canopy component) and the regional pollen transported by stronger air currents above the forest canopy.[7]

Further components of significance have since been recognised. Most reflective of local vegetation (at both bio-stratigraphic and archaeological sites) is the so-called "gravity component" (flora directly above the sampling site), while more-reflective of regional vegetation is the pollen deposited in sediments *via* inflow streams, the so-called "surface run-off component" or "water transport component".[8]

Air transport of pollen at terrestrial and quasi-terrestrial sites

The term "terrestrial pollen site" refers to situations where pollen is carried to a cumulic surface by winds without the intervention of water transport. Three classes of pollen analog study are considered which reflect land clearance and land-use as to:

A. the reconstruction of steppe environments using triangular (linear) models.
B. the empirical limitations of non-tree to tree pollen ratios at terrestrial sites.
C. the relative dispersal efficiencies of syn-anthropic pollen types.

Reconstructions of steppe environments using the Griczuk analog method

The history of the Pannonian steppe in the Northwest Carpathian Basin has been of some interest to palynologists in Moravia, who in using Griczuk's (Russian bog) analogs

7 Tauber 1965, 1967

8 Jacobson and Bradshaw 1981

to interpret spectra from the stream-fed lake sites of Vracov and Mistřín in South Moravia, overlook differences in the taphonomy of pollen in stream-fed lakes and those bog sediments subject to much-less aquatic influx. The latter site types are used by Griczuk towards the construction of a triangular (linear) vegetation reconstruction model,[9] and thus relates (air transport) percentages of tree and non-tree pollen to spores in modern sediments to the relative extent of regional "forest", "forest-steppe" and "steppe" vegetation within the presumed catchment.[10] The "Griczuk analog method" should not be applied to lacustrine situations where aquatic transport of pollen is significant.

As will be reviewed below in reference to Blelham Tarn, lacustrine pollen is largely water-bourne and riparian in origin. Representation of riparian (non-steppic) flora will thus also be favoured at Vracov and Mistřín (cf. Chapter 5), an inference supported by high alder values registered at Mistřín. Application of the Griczuk analog method will thus under-rate the degree of steppic development at such lake sites unless the alluvial woodland is cleared to a degree approximating the inter-fluvial woodland composition.

Empirical limits of non-tree to tree pollen ratios at terrestrial sites

Terrestrial pollen analog studies across landscape zones are useful in assessing the possible land-use indicative values of pollen spectra from archaeological sites. Pertinent data of this sort come from the Leithegebirge, Rosaliengebirge and Wenigzell-Sommersgut transects in East Germany as analysed by E. Lange.[11] The transect at the Leithegebirge is made across wooded hilly terrain with vales of rye-fields, wherein on hilltops, cereal pollen registers only 1 to 2% of T.L.P. (total land pollen), while arboreal pollen (A.P.) comprises 80%. Then along the edges of a clearings, tree pollen plummets to 15%, while cereals and weeds increase to 10% and 55% respectively. Sharp declines in A.P. are also experienced in small clearings in the Rosaliengebirge, where spectra from within both large and small woodlands are identical (ca. 80% A.P.).

A largely local indicative value of terrestrial A.P. percentages is also discernible from the lowland area at Wenigzell-Sommersgut. A series of four samples are analysed at

9 Cf. Rybníčková and Rybníček 1973, Svobodová 1989

10 Griczuk 1950

11 Lange 1971

Wenigzell, first from a field of *Secale cerealia*, where this taxon accounts for 70% of T.L.P. Once within the forest, A.P. rises rapidly to 95%, without a trace of rye. Finally, one small clearing (22 x 8 m) produces a spectrum of 20% non-arboreal pollen (N.A.P.), while a larger clearing some 50 m in diameter registers 50% N.A.P.

Respecting these analogs, it might be inferred that terrestrial pollen deposits are influenced primarily by local vegetation, with regional patterns being obscured. Within the woodlands, A.P. might contribute 80 to 95% of the T.L.P. sum, falling to a 20% "plateau" upon crossing an interior threshold within a larger clearing. It would appear that clearings smaller than 2-300 m in diameter will register the greatest decline in A.P. as these are expanded, with A.P. falling to a (ca.) 20% level around a 2-300 m diameter clearance threshold. After this clearance threshold is crossed, changes in A.P. representation become incremental, if not determined by the production of local N.A.P.

Relative dispersal efficiencies of syn-anthropic pollen types at terrestrial sites

It is important to appreciate the dispersal efficiencies of syn-anthropic pollen prior to palynological reconstructions of agricultural landscapes. To this end, a study of the abandoned Medieval village of Dalem in North Germany provides a demonstration of relative dispersal efficiencies of agricultural pollen types at terrestrial sites. Behre and Kučan study this on the basis of the relative representation of syn-anthropic taxa in (dated) organic sediments at several removes from the abandoned village. Relative pollen frequency is measured against a standard established within the village field system, where relative percentages form a 100% base-line for relative pollen representation in mire sediments outside Dalem. The latter derive specifically from a kettle-hole some 400 m distant, a large raised bog some 1,600 m away and a kettle-hole some 3,000 m in distance from Dalem. High and low dispersal efficiencies are reflected directly in high and low relative percentage values at various distances (see Table 3.1 below).[12]

It is apparent that arable pollen dispersal efficiencies are lower than those of either ruderal or pastoral vegetation classes. In the arable class, the pollen of *Secale cerealia* disperses best, so that a rational response can be expected within 0.4 km of cultivation. Of the ruderals, *Chenopodium* would appear to be most-efficient in its wind-borne transport, so that substantial quantities might be expected at removes from its habitat.

12 Behre and Kučan 1986

The response of *Plantago major* is perhaps skewed, as no explanation as to its high values in the large raised bog can be given at present. Among pastoral pollen types, the entomophilous *Compositae tub.* and the vegetatively reproductive *Gramineae* are less efficiently dispersed, although a low response can be expected at distances of up to 1.6 km from source areas. The pollen of *Plantago lanceolata* fares better at distances under 400 m, although it too experiences a dramatic fall-out before 1,600 m from source areas.

Table 3.1. Relative dispersal efficiencies of syn-anthropic pollen types at Dalem

Class of land-use and pollen type at Dalem	*kettle-hole (@ 400 m)*	*large raised bog (@ 1500 to 1600 m)*	*kettle-hole (@ 3000 m)*
Arable and weeds:			
Cerealia	3.7%	3.2%	0.0%
Secale cerealia	13.6%	1.8%	1.8%
Centaurea cyanus	13.6%	0.0%	0.0%
Spergula arvensis	7.0%	0.0%	0.0%
Fallow and ruderal:			
Rumex acetosella	6.9%	0.7%	0.4%
Plantago major	27.3%	68.2%	0.0%
Artemisia	10. 5%	5.9%	2.8%
Chenopodium	84.0%	47.3%	36.7%
Pasture and dry heath:			
Compositae tub.	14.7%	5.0%	2.5%
Gramineae	22.7%	14.3%	2.9%
Plantago lanceolata	45.7%	9.0%	9.0%
Calluna	56.4%	52.7%	16.9%

These limited dispersal efficiencies should be bourne in mind when interpreting the significance of high N.A.P. at archaeological sites. High N.A.P. values of insect-pollinated (entomophilous) types will not necessarily signify large clearings, while high values of anemophilous types such as *Chenopodium* or *Artemisia* more likely will. The arable use of such clearings will be more difficult to detect, although values of only 2% cereal pollen can be indicative of extensive (multi-hectare) fields within a few hundred metres proximity. Arable land at more than a 1.6 km remove from a terrestrial pollen site is likely to be represented primarily by *Chenopodium* pollen. Generally, pastoral pollen taxa will be more widely registered as a recognisable community.

Sedimentation of alluvial sites

Because primary sites chosen for pollen analysis include alluvial settings, an account of the mechanics of sedimentation within these situations is required. Alluvial accretion deposition is dependent on a complex relationship between aquatic (flow) velocity *vs.* turbulence, the size and specific gravity of particulate matter in suspension and planar (topographic) characteristics of the alluvial accretion surface itself.

Alluvial sedimentological processes begin with erosion through precipitation which preferentially entrains silt particles over clay and sand in the process called sheet-wash, the planar erosion of a soil surface by water.[13] Once entrained, sediment is carried along in suspension until water velocities and relative turbulence drop below a critical threshold, a threshold inversely related to particle size and specific gravity of particulate matter (most importantly, silica has a specific gravity of 2.5). Because the uneven surface of the stream bed floor will most often create a degree of turbulence greater than the fall-out threshold of silts, the channel lag deposits will consist primarily of coarser material (sands and gravels), while the relatively stagnant waters over the over bank or alluvial accretion deposits will cause particles above the median size range of 15 μ to fall out of suspension.[14] Although this size range also includes the vast majority of pollen grains, the lower specific gravity of sporopollenin (after Firbas, this is 0.35 in *Zea*) will require larger average pollen grain sizes for deposition in the same conditions as silicates, namely the coarse clay to fine silt fraction. However, because of the ability of pollen grains to absorb water through their exine, the specific gravity of such grains might approach 1.0 in aquatic situations (after Traverse, also in the case of *Zea*).[15] Because of this latter factor, any alluvial sediment consisting of coarse clay to coarse silt should be expected to contain

13 Morgan 1979

14 Allen 1965

15 Traverse 1988

a representative sample of the pollen formerly carried in suspension. The sorting of pollen by size can be excluded where clay is exclusively deposited, reflecting a situation of little or no actual water flow.

Differential taphonomy of saccate pollen

Further taphonomic dynamics of saccate pollen grains were first recognised by Roger Neves (of the British Coal Board) in geologic deposits of Palaeozoic and Mesozoic age in the U.K. This so-called "Neves effect" refers to the preferential deposition of saccate grains in sediments subject to aquatic in-wash, through the float-characteristics imbued to such pollen grain by virtue of their buoyant air-sacks. In effect, ancient saccate pollen is thought by Neves to float on the surface of the waters rather than in suspension, where upon reaching the shore or telmatic interface, it is collected into the shore as a "film" while non-saccate pollen in suspension is washed back to sea or lake bottoms. A further demonstration of the Neves effect in much more recent shoreline sediments has been effected by Traverse along Galveston Bay on the Gulf of Mexico.[16] It is possible that the differential sorting of water-bourne saccate grains might also occur on alluvial accretion surfaces (see below).

Recruitment of air- vs. water-bourne pollen into lake and river sediment

Of critical importance for lacustrine and alluvial palynology are the studies by Bonny and Pennington regarding the mechanics of pollen recruitment into lake sediments.[17] Bonny's study at Blelham Tarn in Cumbria is of particular interest, a study aimed at ascertaining the source of pollen in lake sediments. Assessments of air-borne pollen recruitment are made by Bonny through the use of floating Tauber traps, while comparative assessments of water-bourne pollen recruitment is made through the use of seston samplers (submerged meshed-tubes set at 2 and 10 m depths). The area within one km of this 10.2 hectare lake is comprised of 25% mixed-oak woodland, with the remainder comprised of relatively open heath vegetation of *Calluna vulgaris*.

Substantially different rates of pollen influx are inferred after the dual recovery from

16 Traverse 1988, , H. Roe pers. comm. 1996

17 Bonny 1976, 1978, Pennington 1979

these mechanisms. Bonny calculates that up to 85% of T.L.P. is recruited into lake-bed sediment through water-bourne sources (streams), while only 15% of T.L.P. is collected onto the lake surface through the gravity-to-regional air-borne pollen components. Furthermore, the qualities of pollen spectra collected by the two mechanisms are quite distinct. "Tauber trapped" air-borne pollen recruitment registers only 40-50% A.P. as a proportion of T.L.P., while the seston sampled water-bourne component registers up to 80-90% A.P. as a proportion of T.L.P. Thus it appears that the higher seston A.P. percentages at Blelham Tarn reflect the greater levels of aforestation to be witnessed adjacent to water-courses. From these observations, two inferences regarding relative pollen recruitment may be derived. First with an increasing limnic surface, the relative proportion of water-bourne pollen will fall as the collection surface for air-borne pollen expands. Conversely, with an increased rate of water influx into lakes, riparian flora will also increase in their relative representation in lacustrine pollen spectra.

In relation to water influx, Pennington also indicates that deforestation increases the relative contribution by the water-bourne pollen component in lacustrine sediment. This occurs because anthropogenic impact entails higher water tables and increased run-off as induced through the reduction of effective evapo-transpiration and the disturbance of soil and root structures. As a result, small stream-fed lakes in deforested agricultural areas produce spectra where the water-bourne component comprises up to 97% of T.L.P.

Self-evidently, pollen spectra in alluvial sediments will be subject to recruitment processes similar to those of sediments in stream-fed lakes.

Elimination of local elements in alluvial pollen diagrams

In respect to the elimination of local elements from the pollen spectra, the presence of reed and sedge communities in the alluvial accretion zone of flood plains makes it reasonable to assume that these taxa will be over-represented in alluvial pollen spectra. These types include *Gramineae* (potentially, those grains smaller than 27 μ may derive from *Phragmites*) and *Cyperaceae*.[18] Also after Bonny, extra-local pollen recruitment at alluvial sites will preferentially reflect places proximal to water-courses up to their watersheds, in other words, their pollen catchment is lineal and dendritic rather than radial. A preferential source of extra-local pollen will thus be the alluvial woodland zone, or as

18 Rybníčková and Rybníček 1971

more land is cleared, emergent pastures and fields as pollen is entrained with fine sediment as a result of sheet-wash and Hortonian overland flow, after Pennington. Pollen is then carried in suspension until its deposition onto an alluvial accretion surface.

Test of the alluvial extension of the Neves effect

As previously speculated, the saccate pollen grains of *Pinus*, *Picea* and *Abies* might be carried on the surface of the stream waters rather than in suspension, potentially leading to significant differences in the mechanism of their recruitment *vis a vis* other land pollen taxa. Because these three conifers occupy quite different environments, with different soil preferences and climatic tolerances, it cannot be expected that their actual pollen production in the landscape and subsequent recruitment into sediment will co-vary to a significant degree. Should these three saccate pollen types strongly co-vary, it might be inferred that these have been culled together onto alluvial accretion surfaces, particularly under lower water tables. Allied responses of alluvial sedimentology and palynology of aquatic, semi-aquatic and telmatic communities may also support this hypothesis.

The palynology of archaeological sites

The problem of differential pollen preservation in archaeological sediments, as well as the dynamics of soil and pollen movement has been studied by Dimbleby.[19] These studies suggest that the preservation of pollen in archaeological sediments is dependent on two factors: soil acidity and the rapid attainment of anaerobicity. Because highly-acidic soils retard bacteriological consumption of pollen grains, pollen samples taken from hyper-acidic areas such as the field systems of Dorset or the Shetlands have been known to contain well-preserved Bronze Age or Neolithic pollen assemblages in even slightly oxidising conditions.[20] For example, one ditch-fill from Fortress Dike in North Yorkshire similarly preserved a distinctive Iron Age pollen assemblage 33 cm from the present-day surface.[21] In basic soils, rapid and deeper burial is required to preserve

19 Dimbleby 1985

20 Cf. Whittle 1986

21 Dimbleby 1985

pollen, for example in the Neolithic earth surface under the South Street long barrow. Differential pollen preservation in sediments is apparent with the appearance of corroded grains, as well as by an over-representation by relatively decay-resistant pine pollen and fern spores. Possibilities of secondary pollen deposition in archaeological settings also needs to be considered when interpreting archaeological pollen data, depending on the potential for pollen preservation in surrounding cumulic soils and sediments.

In the generally basic, oxidised loessic soils of the principal study area (i.e., soils with little intrinsic potential for pollen preservation), conditions more favourable to archaeological pollen preservation were sought out in two situations. First, deep burial situations at the base of ditches, storage pits and deeply-sunken huts were sampled, where the rapid in-fill of sediment following disuse leads to reduced oxidation. Secondly, samples were obtained from bronze artifacts (in graves), where the presence of "copper-salt" (cupric-oxide) toxins has retarded the degradation of pollen through a consequent inhibition of microbial activity. Such archaeologic samples are likely to share recruitment characteristics common to terrestrial sites, although pollen can also be introduced by human activity at settlement features. Finally, pollen from woolen cloth in contact with copper-salts may reflect sheep-grazing habitats (see Chapter 7).

Laboratory techniques

The great majority of pollen samples were prepared using the standard (HF) laboratory technique, requiring an initial pre-treatment with dilute HCL in order to reduce excessive carbonate substance. The addition of exotic *Lycopodium* to the primary bio-stratigraphic sequence at Vranský potok was made for the purpose of comparison of relative pollen concentration in the sediment. The removal of soluble organic substance was achieved through the addition of KOH, with the resultant caustic (with pollen sample) strained through a 171 µ (brass) sieve. Samples with substantial silica (all alluvial and archaeological samples, but not gyttja samples) were treated with HF. The remaining sample, after acetolysis and cleaning, was then treated with a series of alcohol washes, including tetra-butyl alcohol, prior to mounting in a high viscosity silicone oil substrate.

A second technique brought to the author's attention was devised at Southampton Universitty. for the mechanical rather than chemical removal of clay-sized silicates. This method employs sieving and filtration in distilled water and requires two sieve sizes for filtration (10 μ [nylon]) and straining (171 μ [brass]). In principle, a pollen sample is dissolved in distilled water with the addition of (ca. 2-3%) sodium hexa-metaphosphate and is then strained through the brass sieve, discarding the larger fraction. The fine fraction is then filtrated through the nylon sieve, with this fraction retained. The clay solution effluent is then discarded.[22] Initial tests of this method from the pollen sites of Vinořský potok (see Chapter 6) and Včelince (see Chapter 7) yielded spectra statistically identical to those of samples reduced *via* the standard technique.

Research aims of the palynological methodology

After empirical limits defined in this chapter, archaeological and alluvial pollen sites will be employed towards slightly different research aims.

Pollen spectra from archaeological sites are to be employed towards the reconstruction of local environments only (within a 0.5 km radius). Multiple samples from a singular site may be of comparative interest in assessing fluctuations in agricultural intensity at sampled intervals. Because the pollen catchment of arable taxa is definably limited, calculations of minimal areas under cultivation may be made, in addition to inferring a balance between arable and pastoral agriculture after observations of relative agricultural intensity. At archaeological sites, very low tree pollen need not be significant of large clearings, although multiple contemporaneous expressions of such may be suggestive of an open landscape, particularly where aerodynamic pollen (e.g., *Chenopodium* and *Artemisia*) is prominent in the spectrum.

Spectra from alluvial pollen sites will be used in the reconstruction of micro- and macro-regional environments (10^{1-3} km^2). Given the predominant influence of water transport in such situations, pollen may be recruited from areas up to the limits of the water-shed above the sampling site. Areas of human cultivation are likely to be favoured in relative representation as such cultivation also encourages pollen and sediment accumulation (in flood-loams) *via* sheet-wash and Hortonian overland flow. A differential deposition of saccate pollen and an over-representation by local semi-aquatic and telmatic vegetation may require the elimination of such elements from the T.L.P. sum in order that a uniform assessment of the terrestrial flora may be made.

22 D. Coates, Sr. Technician of the Quaternary Research Laboratory, U. Durham, pers. comm., Spring 1996.

Analyses of pollen spectra in both situations will focus on the agricultural, syn-anthropic flora in order to assess prehistoric farming intensity, and indirectly, (relative) population levels. In order of increasing human influence, the components of this flora are designated as secondary woodland, (wet) pasture, (dry) culture-steppe, fallow, weeds of cultivation and primary cultivation. In addition to undifferentiated cereals, the latter group also includes taxa such as wheat, barley and rye, as well as non-corn crops such as flax, hemp and hops. As the area represented by a given pollen spectrum increases, vegetation reconstructions of agricultural history therein are more likely to align with regional settlement trajectories.

4. Later Holocene climate history of Central Europe

In this chapter, the later Holocene climate history of Central Europe will be reviewed on both a long-term (10^3 year) and secular (10^2 year) basis. Modern agro-climatic contrasts between a temperate Hercynian zone and a continental Pannonian one are also considered in this context.

Later Holocene average summer temperatures are reconstructed to have fluctuated by a high-amplitude (4+ degrees C) over periodicities as short as two to three centuries during the post-"Climatic Optimum" in Central Europe. For early crops derived from the semi-arid Near East, such oscillations in a Central European environment might greatly affect arable productivity. Proxy-climate historic sources indicating high summer temperatures or low effective moisture levels are then reconstructed for "maximal" agro-climate periods of the Middle Eneolithic, (later) Early Bronze Age, the Late Bronze Age, the Late Hallstatt (D) period and the Late La Tène or Early Roman period. Intervening "minimal" agro-climates, closer to the adaptive margins of early cultigens, are reconstructed for much of the Eneolithic sequence, the Middle Bronze Age (Loebben oscillation) and most of the post-Bronze Age.

Some perturbations of the thermal maximum of the Late Bronze Age (Urnfield) climate are also discernible at the interface of the Knovíz and Štítary periods, in Czech archaeologic terminology. The former are expressed as a cooler, wetter phase (ca.) 11/1000 cal. BC in absolute terms (cf. Hekla III tephra). Otherwise, the Late Bronze Age comprises the warmest period of the Late Holocene in Central Europe, with average summer temperatures as much as four degrees (C) higher than those enjoyed today. Calculated degree day differentials above 10 degrees C (a critical threshold of effective vegetative growth) range between +250-500 after unpublished (COHMAP) pollen transfer function data for this (ca. 1000 uncal. BC) period.

Modern climate of the Czech and Slovak Republics

The present-day climate of the Czech and Slovak Republics varies primarily according to longitude, altitude and topographic effects. Generally the climate can be described as temperate continental, with warmer summers in Slovakia and slightly cooler summers in Bohemia.[1] Moravia constitutes a transitional province in this respect, the North of Moravia shares the same climate as Bohemia, while South Moravian climate is more closely related to that of Slovakia.

1 Trewartha 1968

Annual mean temperatures between the two regions vary from (ca.) 8 degrees C in Prague to (ca.) 9 degrees C in Brno, on the South Moravian threshold of Pannonia.[2] More important to agriculture is the distribution of higher temperatures during the growing season, this being defined in terms of degree days above 10 degrees C. When considering the number of months per year which experience average temperatures over 10 degrees C, significant differences emerge between Bohemia and Pannonia. Bohemia, belonging to the Middle European agro-climatic region, enjoys five months of temperatures over 10 degrees C, and three months of temperature above 15 degrees C *per annum*. South Moravia and West Slovakia, belonging to the more continental South European agro-climatic region, enjoy longer growing seasons of five and seven months per year of mean temperatures above 15 and 10 degrees C respectively.

Inter-regional differences also emerge in terms of precipitation. In Bohemia, there is usually sufficient precipitation in the summer (July being the wettest month of the year). Pannonian climate is characterised by "just" sufficient precipitation, with more rain falling in May, followed sometimes by a dry late summer. Patterns in winter precipitation vary slightly, the snow cover being less continuous in Bohemia, where January is the driest month. Driest conditions in Slovakia occur later in February, so that more precipitation falls as snow in the coldest months. This increased January snow-cover helps to protect winter crops such as rye, although prolonged snow cover may promote fungus which can damage such crops.[3]

Geographic differences in temperature and precipitation are due in part to the eastern position of the Pannonian territories, encouraging increased continentality. More important, however, are the thermal and rain-shadow effects of altitude and topography. The Bohemian lowlands lie at 200-300 mamsl on average, those of Danubian South Moravia and Southwest Slovakia lie at only 150-200 mamsl, producing higher average temperatures in Danubian Pannonia. Exceptions are illustrative, for example the low-lying basin of Litoměřice behind the Czech Middle Mountains shares some climatic characteristics of Pannonia. Generally, Pannonia will have lower precipitation due to rain-shadow topographic effects of the Alps, Tatras and the Bohemian highlands. Pannonian precipitation rates vary largely as a function of elevation, from 450 mm *per annum* in lowland Danubia to over 1000 mm *per annum* in the high Tatras.

These zonal contrasts lead to expectations that climate change would have differential impacts on agriculture. Bohemia, with a shorter growing season and adequate precipitation would be

2 Rudolf 1981. Mean annual temperatures in Southwest Slovakia may be higher (up to 10 degrees C, cf. Tran and Broekhuizen 1965).

3 Bourke, A. 1984, Zohary and Hopf 1988

more sensitive to cooler and wetter conditions, while Pannonia benefits to a lesser degree from higher temperatures, although precipitation is likely to be a limiting factor in this zone.

Little Ice Age climate in Central Europe

Historical accounts of the "Little Ice Age" interval from the Late 16th to Early 18th Centuries provide some illuminating impressions as to the potential effects of inclement weather on arable agriculture and viticulture in Central Europe. At the height of this climate period, accounts of total (wheat) crop failure are common, the causes of which include not only low summer temperatures, but also abnormal precipitation.[4] Thus in the summer of 1596, when after a promising spring there falls an abnormal quantity of rain in June to July, a poor wheat crop in Bohemia results. Moravia, which registers far fewer complaints than Bohemia altogether, enjoys a "sufficient" harvest at this time.[5] In fact, the Carpathian Basin as a whole is quite differently affected during this interval, where complaints of <u>insufficient</u> precipitation are frequently recorded. So concerned are the Hungarian peasants in 1728, that there occurs a series of witch hunts for those guilty of "selling the summer rains to the Devil".[6]

Bohemian viticulture is also adversely affected, although the low-lying Litoměřice Basin enjoys "a good wine" when Slány (<u>up</u>-valley ca. 30 km west) enjoys only mediocre returns. An absence of any mention of failure in the Bohemian <u>rye</u> crop is significant, as this cultigen possesses a wider edaphic tolerance in comparison with wheat.[7] A widespread disruption of European agriculture by the Little Ice Age is well-documented, although the question remains as to whether the farmers of later prehistory suffered from similar episodes.[8]

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4 A similar pattern emerges during the earlier (ca. AD 1250) Sporer Minimum (cf. Eddy 1976), during which the district of Litoměřice experiences heavy flooding. During this climate minimum, five villages in the Lower Ohře valley are inundated and abandoned due to floods, a result of abnormally high rainfall on exposed arable tracts (Kotýza 1991).

5 Munzár 1992

6 Racz 1992. This drought-effect may be the result of depressed late summer anti-cyclones resulting from lower growing season temperatures.

7 Pfister (1981) records episodes of failure in the rye crop in Switzerland, due to the growth of fungus under prolonged snow cover.

8 Cf. Grove 1988 and Parry 1978. Piontek (1992) also reports speculatively on the osteological effects of the earlier part of the Little Ice Age on the health and stature of cemetery populations in various parts of Poland. The example of Late Medieval cemeteries from Silesia illustrates how the estimated 1.5 to 2 degrees C decrease in mean annual temperatures produced an up to 4 cm decrease in average stature, after a phase lag of about 20 years. Here one might suppose that an over-all decrease in the *K* capacity of the environment has led to a distribution of nutritional stress through the mass of the peasant population.

Reconstructing later Holocene agro-climates in Central Europe

Reconstruction of later Holocene climate history in relationship to prehistoric agrarian settlement in Central Europe depends on a wide array of independent sources: morphological, bio-stratigraphical and archaeological, dated by means of cultural association, radio-carbon, or more rarely, dendro-chronology. The problems of associating morphological and bio-stratigraphical evidence with the archaeological sequence are four-fold. Firstly, it is not always possible to correlate the relative culture sequence with radio-carbon or absolute dates. Secondly, even when a particular archaeological phase is well-defined in radio-metric or absolute terms, their time spans (100 to 250 years) make difficult any certain correlation with radio-metric dates. Thirdly, the morphological and bio-stratigraphic records of climate are themselves often poorly dated, with the duration of particular climatic episodes undefined. Finally, the indicative value of different proxy evidence varies quite substantially, meaning that conflicting signals in the comprehensive record may occur independent of chronology.

Despite these difficulties, two facts remain certain. Firstly, the climate of Central Europe has become much cooler since the Middle Holocene. Secondly, punctuating this long-term trend are secular oscillations of one to three century duration, during which palaeo-climate becomes significantly warmer, or cooler still.

Secular and long-term indices of proxy-climate history will now be considered. The former includes morphologic evidence for neo-glaciation and oscillations of fluvial systems, lake-level data and oxygen isotope fractionation data from rain-fed tufas. The latter is comprised of palynological evidence for long-term patterns of vegetation change, including pollen transfer function data of COHMAP. Finally, an array of archaeological (and largely secular) indices of later prehistoric environmental change will be considered (cf. Figs. 17-18 for site maps).

Secular morphological evidence from neo-glaciations and ablations

Morphological proxy evidence for palaeo-climate derives primarily from the Alpine neo-glaciations subsequent to 4000 uncal. BC. Between 6400 and 4000 uncal. BC, high altitude (2510 m) peat deposits in the West Italian Alps indicate an extreme contraction of ice masses.[9]

Subsequent, Late Holocene neo-glaciations reflect the build-up of ice masses within glaciers

9 Porter and Orombelli (1985) date the peat deposition in the ablation zone of the Rutor Glacier, however, upper peat layers are severed by subsequent neo-glacial advances. This Alpine peat deposition reflects July temperature conditions some 4 degrees C warmer than today (cf. Huntley and Prentice 1988).

beyond a critical threshold. This build-up of mass balance is due primarily to falling summer temperatures, discouraging the melting of ice, and secondarily due to increased winter snow-fall, which increases mass balance.[10] After passing an equilibrium threshold, the ice-masses advance down-slope churning-up debris which is accumulated into lateral and end moraines. Multiple glacial advances might terminate on the same moraine in a super-imposed fashion, or later advances may erase traces of prior events. In the latter case, lateral moraines may be preserved. The organic debris of moraines may be assayed, producing maximum limiting dates for the advance. Organic accumulation above the moraine may also be used to produce minimum limiting dates for the ablation of the glacial masses. Alternatively, sedimentology (e.g. solifluction) in pro-glacial areas may be investigated and sampled in order to provide bracketing radio-metric dates for these same phenomena. Chronological ambiguity may arise from lag times (as great as 50 years) between the onset of cooler conditions and actual glacial advance. Furthermore, glacial masses may remain in place up to a century after the return of warmer conditions.[11]

Neo-glacial activity is first recorded from the East Alpine zone in the Frostnitz advance, with a maximum limiting date of 4180 +/- 130 uncal. BC produced from macro fossils of *Pinus cembra* in lateral moraine deposits of the Vendigergruppe. These moraines are of small size, suggesting that this cooling event was also of limited magnitude. Subsequent evidence of neo-glaciation recurs at (ca.) 3350 to 3000 uncal. BC, and again from 2850 until 2550 uncal. BC, the Rotmoos I and II oscillations respectively. The subsequent Loebben oscillation has been dated in the Austrian and Swiss Alps to 1400 until 1200 uncal. BC, when end moraines advanced 150 m down-slope of those of the Little Ice Age.[12] Additional evidence from the Austrian Alps derives from pro-glacial buried peats, which provide a maximum limiting date of 1490 +/- 60 uncal. BC, these being buried by glacial outwash gravels. During the First Millennium uncal. BC comes the (difficult-to-date) neo-glaciation referred to as the Goeschner I event. Chronologically, this "event" may be persistent. In the Stubier Range for example, debris from the snout of the Fernau Glacier intruded into a bog, the underlying woody detritus of which

10 Süter (1982) analyses the effects of climate on glaciers in a comparative study of historic glacial advances and weather records from the Swiss Alps. His findings suggest that the expansion of glaciers is highly correlated with lower summer temperatures ($r > 0.9$), less so with higher winter precipitation ($r = 0.7$ to 0.8).

11 Grove 1988

12 Nesje and Dahl (1993) record a similar episode in the pro-glacial area below the Jøstedalsbreen cirque glacier in Western Norway. A series of laminated sand and silt deposits have been associated with summer melting episodes of this glacier, calibrated ^{14}C assays date this activity from ca. 1500 to 1260 BC .

provided a maximum limiting date of 950 +/- 60 uncal. BC. A minimum limiting date for the retreat of this glacier derive from organic deposits (producing an assay of 100 +/- 80 uncal. BC) above pro-glacial silts.

Secular oscillations of Alpine and Carpathian tree limits

Closely allied to the morphological evidence for neo-glaciation are the bio-stratigraphic data for oscillations in the Alpine tree limit. Like the glacial cycle, these oscillations have been closely linked to variations in Alpine mean summer temperature, which constitutes the primary limiting factor upon the growth of Krumholz taxa such as *Larix* and *Pinus*.[13] The interpretation of such oscillations in the proxy pollen record encounters several complications, although analog studies from the Swiss Alps have shown that the potential significance of up-slope transport of pollen of lowland woodlands has been somewhat exaggerated.[14] The interpretation of past fluctuations in the Alpine tree limit thus depends on deriving the elevation variation of such limits from changes in the relative pollen contribution of the alpine-steppe *vs.* dwarf woodland components at highland sites. Respecting the potential effects of upland grazing, there is little evidence for land-use above 1500 mamsl until the Late Bronze Age.[15]

Records of Alpine tree limit fluctuations derive from both the Alps and the Tatras. Pollen data from the Central and Eastern Alps record only minor depressions in the Alpine tree limit during the Middle Holocene, when *Pinus cembra* and *Larix sp.* gradually ascend to 2300 mamsl.[16] The forest belt below also changes in its composition, as *Pinus sylvestris* is replaced by *Picea* at (ca.) 2000 mamsl in the Eastern Alps after 5000 uncal. BC. A bi-pulsatory 200 m depression of the Alpine timber line is then recorded in the Central and Eastern Alps at 3500 and 3300 uncal. BC respectively (Rotmoos-Piora I and II). The Krumholz only partially recovers its lost ground before falling once more to 2100 m at (ca.) 3000 uncal. BC in the Central Alps, where *Pinus cembra* is also replaced by the moisture-loving *Alnus viridis*. The records from the Eastern Alps are unclear, although in the Oetztal, a decline in the Alpine tree limit may date to as late as 2250 uncal. BC . After 2800 uncal. BC in the Swiss and Austrian Alps, there is a gradual recovery of the tree line to a 2150 m elevation, until another sharp decline of 150 m correlated

13 Tranquillini 1993

14 Markgraf 1980

15 Behre 1988

16 Burga 1988, 1993

with the Loebben oscillation is registered at (ca.) 1400 to 1200 uncal. BC. Thereafter, the tree limit rises to 2150 mamsl in the Central Alps until 1000 uncal. BC, after which there is a catastrophic fall of 300 m due to human impact.

Comparative timber line fluctuations in the Tatras are poorly dated. The upper tree line at (ca.) 1900 to 2000 mamsl sees the replacement of *Pinus cembra*, *Larix sp.* and *Juniperus* by *Picea* during the Middle Holocene. The former edaphic limit has been imposed due to a lack of adequate soil cover rather than climatic factors. *Pinus cembra*, *Larix sp.* and *Juniperus* first reappear below the edaphic limit of (ca.) 1900 to 2000 mamsl during the late third Millennium uncal. BC These sub-alpine communities have since descended to (ca.) 1450 mamsl due in part to the impact of highland grazing in Slovakia.[17]

Dendro-chronological densitiometric studies of Alpine conifers

Closely allied to evidence of Alpine tree limit changes are variations in the cellular densities of late spring to early summer growth in tree rings of *Pinus* and *Picea*. The density of cellular growth in these taxa is strongly correlated with summer temperature. This limited sequence consists of floating dendro-chronological segments which concord with the record of tree limit fluctuations.[18] For example, a dramatic decrease in the density of late season growth is demonstrated over a fifty year period after 1390 uncal. BC, or the time of the Loebben Oscillation. A rapid rise in temperatures of the Early Urnfield period (ca. 1200 uncal. BC, cf. Table 14.2) is interrupted around 1000 uncal. BC, or the Knovíz-Štítary transitional period.

Secular lake-level fluctuations

Lake shore settlements are a further source of palaeo-climatic data from the sub-Alpine zone. Dating from the Late Neolithic until the Late Bronze Age, these sites (situated directly on the lake shore) can be used in the reconstruction of ancient lake levels.[19] Due to subsequent fluctuations in lake levels, large numbers of timber-rich sites have been discovered, and these have subsequently been dated by dendro-chronology. Because these settlements closely track lake

17 Rybníčková and Rybníček 1993

18 Kaiser 1991

19 Sakellardis 1979

shore fluctuations, timbers deposited during periods of low lake levels will be preserved, being subsequently inundated to a greater degree. A scarcity of preserved timbers can be interpreted as a result of relatively high (lake level) placement. Higher lake levels then follow from lower summer temperatures or higher annual precipitation. Lower lake levels follow from the reverse (cf. Fig. 14).

Swiss and Bödensee (lake-) level fluctuations and alder carr formation

Swiss lake sites also provide corroborative pollen evidence for environmental change, particularly that of alder carr vegetation (which responds rapidly to hydrological change).[20] "Wet" horizons of alder carr formation have been dated to after 2200, 1400 and 500 uncal. BC, while "dry" phases are noted (ca.) 2500 and 1800-1400 uncal. BC. In addition, an episode of "extreme dryness" is recorded (ca.) 1000 uncal. BC, contemporary to the Late Bronze Age (cf. Fig. 15).[21] The lake level reconstructions for the Swiss lake dwellings correlate well with the palynological data, with a sharp rise in timber remains and an apparent lowering of lake levels during the earlier part of the Late Bronze Age.[22] A considerable fall-off in site numbers occurs during Hallstatt B1 (after 1100 cal. BC, or Hekla III?), followed by a recovery in site numbers during the later part of Hallstatt B, dating from *circa* 1100 to 800 cal. BC.[23] The Hallstatt C period witness the complete abandonment of this mode of settlement.[24] An identical pattern emerges over the longer term in the studies of lake dwellings by the Bödensee. The sites at the Bödensee lie at a somewhat lower elevation (306 m) and are fed by the upper reaches of the Rhenish system. Ninety-three sites have been dated *via* tree-ring studies, which indicate that

20 Magny (1982) discusses certain "contradictions" between changes in hardwood forest composition and apparent "dry phases" as expressed in the lake shore settlement evidence in this context, although one must remember that such forests develop along longer-term time-scales than the more secular variations outlined above. Thus, the expansion of *Fagus* is a response to a long term climatic cooling, although this is further constrained by its slow migration rate (see Table 4.1), as well as potential meta-stability of forest conditions, so that secular periods such as the Late Bronze Age need not result in an in-phase arboreal floral response. The response time of the secondary alder carr vegetation is not so constrained by phase lags, and thus is more sensitive to more secular variations in climate.

21 These phases also correlate well with the "dry" phases reconstructable from Rösch's (1988) Bödensee data.

22 Bouzek n.d., 1993. These dates are expressed in calendar terms, being derived from dendro-chronological studies.

23 Recent dendro-chronological studies from the Swiss Lakes suggest that the Hallstatt B period develops just before the turn of the Millennium 1000 uncal. BC . A lack of dendro-chronological data after the latest Hallstatt B horizon, dating to 838 uncal. BC , lend support to the high chronology for the Urnfield Bronze Age (Harding and Tait 1989).

24 In other words, at the beginning of the Eighth Century uncal. BC (ibid.).

lake levels have fluctuated periodically since the establishment of (Late) Neolithic settlement.[25] From 4000 to 2750 cal. BC, there is a regular periodicity to the cycle of peaks and troughs of dendro-date density. Peaks, indicating higher rates of evaporation in relation to precipitation, occur six times at 200 calendar year intervals. A pronounced peak appears at 2950 cal. BC (Middle Eneolithic), followed by a long phase without tree-ring evidence after 2750 cal. BC, coeval with the 2200 uncal. BC "wet" phase in the Swiss Lakes (Corded Ware Culture).[26] The Early Bronze Age (A2) "dry" phase (after 1800 cal. BC) anticipates yet another hiatus *circa* 1500 cal. BC. This (Middle Bronze Age) hiatus corresponds to a "wet" phase in the Swiss lakes and the Loebben oscillation in the Swiss and Austrian Alps. Importantly, wood remains of the Late Bronze Age is extensively represented, although after the Hallstatt C period (after 850 cal. BC), no further lake shore settlements are established (cf. Fi. 14).

Secular morphological evidence from the Central European river valleys

Further morphological evidence for ancient hydrological change comes from cut-and-fill deposits in the upper reaches of the Central European river systems which have been studied by Starkel.[27] Because of the complexity of tectonic, base sea-level, sedimentological, climatic and anthropogenic factors acting on the lower reaches of the river systems, Starkel has concentrated upon the foreland sections of these valleys. These sections lie outside zones of dramatic tectonic movement, early human impact on the sediment supply and the coasts. Starkel proposes a model of the sequence of cut-and-fill episodes of the Central European Mittelgebirge which depends on climatically sensitive upstream processes. In this zone of moderate tectonic uplift, processes of down-cutting are high-lighted without becoming a dominant feature, although aggradation of stream beds with fill derived from the Alpine zone still occurs whenever the sediment supply increases. Slight tectonic uplift also alleviates the problems posed by gradual alluviation, which could depress the slope aspect of the river channel and affect depositional processes independent of upstream (climatic) controls. The major variables driving the cut-and-fill sequence thus are sediment supply and discharge. Where the former variable is of a greater magnitude, aggradation (fill) occurs, where the latter variable dominates, erosion (cut) follows.

25 Rösch 1988

26 Ibid. Cf. also Hardmeyer (1992) for a review of the dendro-chronology of the A-Horizon of the Corded Ware Culture as reflected in finds from Eastern Switzerland.

27 Starkel 1966, 1984, 1987a, 1987b, 1988 and 1991.

This sequence is clearly visible in the stepped terraces of most of the mountain-fed river systems from the Upper Vistula to the Upper Danube.

The primary control on sediment supply in the Alpine zone is temperature. As cooling occurs, there is an increase in potential sediment supply as vegetation cover on montane slopes wanes. Conversely, as warming occurs, there is a recovery of such vegetation, leading to a reduction of potential sediment supply. Changes in discharge also follow (inversely) variations in sediment supply, rather than variations in precipitation, because an increased sediment load leads to a loss of water *via* alluviation in the upper reaches of the mountain foreland which is more significant than relative changes in rain- and snow-fall. Thus, mean discharge rates in the upper reaches of the mountain foreland increase during warmer periods, and because the rate of discharge outstrips sediment supply, erosion (down-cutting) results. With cooling comes an increased sediment load, which is deposited broadly from the lower mountain slope along the long profile of the river valley. Once the slope aspect declines, there is an increased tendency to deposit suspended sediment as alluvium. This process is particularly pronounced in the upper reaches, leading to terrace formation. Gradual tectonic uplift super-imposed on this pattern produces a step-like series of terraces whose organic detritus can be dated.

The terraces produced by accumulation would appear to be coeval over wide areas of Central Europe. Horizons dating to 4000 to 3200 uncal. BC and 2200 to 1800 uncal. BC are indicative of relatively cool Alpine and sub-Alpine conditions. Intervening periods witness the erosion of terraces, and are associated with warmer periods from (ca.) 4500 to 4000 uncal. BC, between 3200 and 2400 uncal. BC (in two distinct phases) and after 1800 uncal. BC. Accumulation, despite evidence for higher discharge rates, dominates after (ca.) 1000 uncal. BC due to the extensive agricultural activities of later prehistoric farmers. The first erosional horizon correlates well with the Middle Holocene Climatic Optimum, but the pattern in the Third Millennium uncal. BC is complex, characterised by multiple fluctuations during its earlier part. A 400 radio-carbon year cool interval at the turn of the Second Millennium would agree with evidence for a long "wet" phase at the Swiss lakes and the Bödensee, while the subsequent return of erosional conditions after 1800 uncal. BC would correspond to the 1800 uncal. BC "dry" phase in both lacustrine areas.[28]

28 Starkel 1988, 1991

Secular-periodic oxygen isotope studies of South Polish tufa deposits

Oxygen isotope evidence for palaeo-climate derives from four deposits of carboniferous tufa investigated by the Geographical Institute at Kraków. These sites lie in a limestone-rich löss belt to the north of the city.[29] Tufa deposits at these sites lie adjacent to precipitation-fed springs, where ambient water temperature is closely related to atmospheric conditions. The ability of tufa to absorb the heavier ^{18}O isotope during the this process of precipitation is directly temperature dependent in that fractionation occurs during the physical process of precipitation.

Fractionation results from the differential frequencies at which lighter molecules resonate *vis à vis* those bearing the heavier isotope (^{18}O). In physical, chemical and biological processes, this differential will lead to a bias against the fixation of molecules bearing such heavier isotopes. However, as the ambient temperature rises, the higher energy environment reduces the relative importance of this effect, thus the proportion of ^{18}O in the precipitate will rise according to a known constant.[30] With the determination of the age and relative ^{18}O content of the calcareous deposit, radio-metric analyses should yield fairly accurate readings of past temperatures derived from precipitation-fed ground waters, and thus also the past atmospheric conditions, all other factors being constant.[31] An important independent variable to consider in this respect is deforestation in later prehistory. Because the forest canopy maintains ground waters at lower temperatures, the cutting of woodland will raise the temperature of spring water which supplies calcium carbonate precipitate. An artificial raising of the ambient temperature at the point of precipitation will reduce the fractionation effect. Because there is a considerable body of evidence to suggest that forest cover first declined appreciably during the Late Bronze Age, one might infer that <u>prior</u> readings are biased towards <u>lower</u> temperatures.[32]

29 Pazdur et al. (1988) have investigated three sites from the Krakowian Uplands and one site in the Racławka valley. The deposits investigated include both calcareous muds and tufas fixed by algal bodies (oncoids and stramatolites).

30 Cf. Grey 1981

31 Thorpe (1980) also discusses the potential physical factors affecting the oxygen isotope ratios at spring-fed tufa sites in the UK. Most significant amongst these factors is the kinetic effect of differential ^{18}O composition of water at the point of deposition. The kinetic effect depends on energetic variation in the water-flow regime. More turbulent flow regimes encourage the diffusive escape of carbon dioxide from water, so that as turbulence increases, so does the proportion of heavier oxygen isotopes lost which might otherwise react to form the calcium carbonate precipitate which is ultimately deposited as tufa. A further factor of variation considered only in passing by Pazdur et al. (1988) is the effect of potential changes in atmospheric circulation. Surface studies from Europe and Africa prove that ^{18}O as a constituent of the moisture-laden air is depleted as one proceeds inland from the sea from west to east (Sonntag 1980).

32 Butzer (1980) cites an increase in flood-loam deposition *via* extensive agriculture during the Late Bronze Age of Central Europe, while Starkel (1991) cites similar phenomena for the Vistula Valley closer to these sampling sites. In addition, pollen studies in Little Poland also indicate a Late Bronze Age deforestation (Ralska-Jasiewiczowa 1977).

The periodicity of the ^{18}O fluctuations agrees with other lines of evidence (Table 4.3 below). Periods of interrupted tufa deposition thus coincide with a (bi-modal) pulse of quite cold climate between 3500 and 3000 uncal. BC (Early Eneolithic), an enduring period of cooler climates around 2200 uncal. BC and a period of cool and wet conditions in the middle of the First Millennium BC. Likewise, isotopic evidence for warmer palaeo-temperatures aligns with reconstructed agro-climatic maxima up to 3500 uncal. BC (Neolithic), between 3000 and 2500 uncal. BC (Middle Eneolithic), (ca.) 1000 uncal. BC (Late Bronze Age) and the First Century AD (Early Roman period). Specifically after the tufa evidence, a very warm phase occurs in the Middle Holocene, with temperatures <u>at least two to three degrees C above those at present</u>, when a rapid rate of algal tufa deposition also attests to hotter and more humid conditions, the rate precipitation being largely dependent on climate.[33] Minor perturbations in the regime of tufa deposition are noted at Rzerusnia (dating to between 4500 and 3560 uncal. BC) which may signify a shorter period of lower temperatures sometime during the Neolithic (cf. Frostnitz advance). More significant interruptions in the regime of tufa deposition are anticipated by significant drop in the ^{18}O ratio between 3500 and 3000 uncal. BC (Piora I-II), signaling the end of this optimal period. A renewal of tufa deposition occurs sometime between 3000 and 2500 uncal. BC, with summer temperatures one to two degrees above those at present. Further cooler episodes with marginal tufa deposition are recorded (ca.) 2200 uncal. BC, although precipitation resumes at temperatures about two degrees above those at present during the period 2000 to 1500 uncal. BC. Unfortunately, poor radio-metric controls preclude the detection of finer signals such as the temperature decline registered in the Baltic tufas from Gotland <u>after</u> 1500 uncal. BC (cf. Loebben Oscillation). Much clearer is the pronounced ^{18}O signal dating to (ca.) 1000 uncal. BC (Late Bronze Age), indicating temperatures at least <u>four degrees C higher</u> than those at present. This last period of intensive tufa build-up is followed by a complete interruption in its deposition between 700 and 400 uncal. BC. Modest tufa formation is renewed during the First Century AD (Early Roman period), with a rise in spring water temperatures up to two degrees C above those at present, after which deposition ends.

Generally speaking then, the dominant palaeo-climate pattern is thus one of high-amplitude secular variation, although average summer temperatures have declined in the long-term since the Middle Holocene, after comparative pollen and pollen transfer function data (see below). Archaeological evidence presented at the terminus of this discussion also reinforces this pattern

33 The deposition of calcareous muds is less-subject to temperature controls, such deposits are still forming in relatively cool inter-mountain conditions in Afghanistan for example (Dr. I. Evans pers. comm., 1994.).

recognition of significant century-level time-scale climate change which is super-imposed on longer-term (millennium-level) tendencies towards climatic cooling.

Long-term indices of climate change

Other (non-archaeological) indices of lowland palaeo-climate are too broad or intermittent in chronological resolution to detect patterns of century-level time-scale oscillations. The former include untransformed, comparative pollen data and pollen transform function analyses of ancient vegetation composition. Of transfer data from the COHMAP project, only the interval at 1000 uncal. BC falls within the scope of this work.[34]

Comparative pollen data

The use of pollen data for the reconstruction of palaeo-climates has been queried on a number of grounds. These include the problematics of migration rates (positive response), relative floral response times to climatic change and the potential impact of prehistoric farmers on the landscape (negative response for A.P. taxa, positive response for N.A.P. flora).[35] Within these empirical limits, the potential utility of pollen analytical studies lies in the relative density of sampling sites, which include upland sites less subject to human influence.[36]

Pollen response to climatic amelioration is constrained by migration rates which can be factored into the complex transform functions as applied by B. Huntley of COHMAP to over 200 bio-stratigraphic sites in Continental and Atlantic Europe.[37] These positive response times vary according species and climatic and geographic conditions. The question of human influence on lowland flora remains problematical, although application of the pollen transform function methodology to floral history on both sides of the Atlantic is illustrative. In this case, where one might expect a similar regional experience of climate change, the response rates of related taxa are remarkably similar (cf. Table 4.1 below).[38]

34 Cf. Barber 1991, Guiot et al. 1993

35 Wijmstra 1978

36 Behre 1988

37 Huntley 1988, 1990, n.d., Huntley and Prentice 1988, 1993.

38 Huntley et al. 1989, Bartlein et al 1986

Table 4.1. Holocene migration rates of major tree taxa in Continental and Atlantic Europe[39]

Pollen type	*Estimated migration rate*
Pinus	more than 1.5 km/year
Corylus	ca. 1.5 km/year
Alnus	0.5 to 2.0 km/year
Ulmus	0.1 to 0.2 km/year
Quercus	0.075 to 0.2 km/year
Fagus	0.25 to 3.0 km/year
Tilia	ca. 0.13 km/year
Carpinus	highly variable through time

Climate and forest history in Central Europe

Climatic reconstructions from forest history are broad in their chronological scope. The pioneering work of Firbas in the reconstruction of the forest history of Central Europe relies on the correlation of pollen assemblages from dozens of different bio-stratigraphic sites. Firbas introduces a system of pollen zonation (still in use today) which is based on the inferred reaction of different species to global climate change. These pollen zones include the Early-Middle Warm Period ("Climatic Optimum", Middle Atlantic or P.A.Z. 6), the Late-Middle Warm Period (Late Atlantic or P.A.Z. 7), Late Warm Period (Sub-Boreal or P.A.Z. 8) and the Post-Warm Period (P.A.Z. 9).[40] This complex history of in-migration and inter-specific competition between tree species yields some valuable insights into the structure of past climates which are not always apparent in other records. These include the seasonality of precipitation and the relative contrast between summer and winter temperature.

Initially, the mixed-oak forests of the Warm Period (Neolithic) contain a high proportion of thermophilous tree species such as *Tilia* and *Ulmus* which thrive best in hot summers. In East-Central Europe there are also significant stands of lowland pine, a sign of predominantly continental conditions. The rapid expansion of *Picea* in the highlands at this time would substantiate this proxy-climatic inference, for this taxon tolerates very cold winters and warm

39 After Huntley and Birks 1983

40 Firbas 1949, 1952

summers.[41] Accordingly, vegetation belts of highland areas such as the Bohemian Ore Mountains appear at much higher elevations during the Middle Holocene. For example, macro-fossils of *Corylus* occur in upland peat bogs 300 m above the present edaphic limit of this taxon. Because the oceanic proclivities of *Corylus* also presently restrict it to Maritime Europe, this evidence suggests that more effective moisture reaches the uplands in the Middle Holocene. After the thermal effects of the latent heat of condensation of the moisture laden air, relative temperatures in highland regions would also be higher after adiabatic lapse rates.

Subsequent forest evolution tracks a progressive deterioration in climate. Beginning in the upland zone, there is a progressive replacement of *Picea* by *Abies*. Because the latter taxon is less tolerant of summer dryness, its expansion must be taken as evidence for increasingly oceanic climatic conditions. The expansion of *Abies* into the uplands of Bohemia is largely accomplished by the Late Warm Period (i.e. Eneolithic and Bronze Age). The expansion of *Abies* into lower lying areas during the Iron Age must surely be indicative of lower summer temperatures in the same places settled by later prehistoric farmers. *Fagus*, which thrives in climates with mild winters, also expands rapidly in the Late and Post-Warm Periods as it partially replaces *Quercus*, *Tilia* and *Ulmus*.[42] The fact of the expansion of *Fagus* and *Abies* further attests to lower summer temperatures and a reduction of seasonal temperature gradients in Late Holocene (Iron Age) times.[43]

Iso-pollen reconstructions of Central European environments

More recent iso-pollen map compilations of the bio-stratigraphic record by Huntley have elaborated upon the above pattern of vegetation development.[44] Reconstructed at 1000 radio-carbon year intervals, an expansion of *Fagus* and *Carpinus* into the territory of the former Czechoslovakia occurs after 4000 uncal. BC. The period of (ca.) 3000 uncal. BC (Early Eneolithic) sees the continued expansion of *Fagus* in Bohemia, while *Abies* and *Chenopodium*

41 *Picea* also thrives during the later Atlantic period at Doksý in North Bohemia, a lowland wetland region (Jankovská 1992).

42 Rybníčková and Rybníček (1989) reconstruct similar histories of upland vegetation development in South Bohemia, the Südeten and Tatra sub-mountain belts as well as the Bohemian-Moravian Highlands.

43 Here post-disturbance expansion follows from the superior competitiveness of the *Fagus* and *Abies* in an edaphic context in which the mixed-oak forest is still capable of perpetuating itself. With the clearance of such woodland by prehistoric farmers, subsequent forest regrowth will favour *Fagus* and *Abies*.

44 Huntley 1990, n.d.

(steppic) communities arise in the Hungarian Plain. This progression can be interpreted as evidence of lower summer temperatures, which would encourage the colonisation of *Fagus* at the expense of the waning mixed-oak woodland. Likewise, cooler summer (anti-cyclonic) air masses penetrating into the steppe from the continent would contain less moisture, leading to reduced precipitation and encouraging the emergence of the steppe.[45] However, the period at 2000 uncal. BC (Terminal Eneolithic) presents a picture of generally wetter climate, with the appearance of patches of *Picea*, *Pinus*, *Betula* and *Alnus* floral assemblages in parts of Central Europe. Subsequently, the floral history at (ca.) 1000 uncal. BC (Late Bronze Age) sees the renewed expansion of the dry steppe on the Hungarian Plain, as well as the appearance of forest-steppe biomes in the Central German Trockengebieten.

With respect to the higher summer temperatures reconstructed for this Late Bronze Age period, the expansion of steppe in continental and hydrologically sensitive areas might have been a result of higher summer evaporation rates or human perturbation of the forest canopy which helps to shield ground water from evaporation.

By (ca.) AD 1, there is a northward migration of *Carpinus*. Its decline in the Balkans indicates that climate conditions in the Carpathian Basin have become more continental. During this same period, *Fagus* expands into the lowland forests of Central Europe, signifying more oceanic conditions in this region. The long-term trend thus suggests that circulation patterns become weaker as the Holocene progress from its Middle to Late stages, perhaps as a result of reduced solar isolation, which in turn reduces the heat differential between land and sea that helps to drive westerly air flow. Increasingly continental conditions in the east, with a reduced penetration of the moisture-laden air masses, encourages the development of steppe even as conditions in West-Central Europe becomes altogether wetter, as the general climate becomes universally cooler. The seasonality of this latter cooling effect is also significant, in that the floral history indicates that summer temperatures in particular are depressed.[46]

Climatic parameters (ca.) 1000 uncal. BC as assessed by the COHMAP project

Quantitative studies of relative changes in different palaeo-climatic parameters have also been undertaken by Huntley of the COHMAP project, using 3,000 year sampling intervals.[47] For

45 Cf. Lamb et al. 1966

46 Cf. Gentilli 1952, Parry 1978, Lamb 1981 and Bourke 1984

47 Huntley n.d.

the period (ca.) 1000 uncal. BC, Huntley derives reconstructions for three climatic parameters from transfer function analyses of regional pollen data bases, two of which are pertinent to conditions for agriculture. Transform functions of pollen data presume that present soil distributions and their moisture retaining characteristics reflect those of the past. Pertinent palaeo-climate parameters reconstructed include:

1. Actual/potential annual evapo-transpiration relative to today
2. Degree days over 10 degrees C (a critical threshold for vegetative growth) relative to today

The un-smoothed data for these parameters at 1000 uncal. BC (corresponding to the Late Bronze Age) reveal a pattern of inter-regional palaeo-climatic variation which only partially agrees with other palynological reconstructions. For the 1000 uncal. BC period, the ratio of actual to potential evapo-transpiration in Central Europe is not too divergent from today's values. Bohemian values of - 0.1 to + 0.0 attest to marginally drier conditions, while higher values of + 0.0-0.1 in Central Germany attest to marginally wetter conditions. Southern Poland's "pre-smoothed" data are consistent, and suggest that evapo-transpiration rates are similar to those of today, while in South Moravia, COHMAP members project somewhat higher rates (+ 0.1). On the Great Hungarian Plain, evapo-transpiration rates are also reconstructed to be relatively higher than those of today , with values ranging from + 0.0- 0.2. These data suggest that Middle Europe experiences only a moderate degree of growing season "dryness" during the Urnfield period, in contrast to data sources which are influenced by human activity.

Fully in agreement with other lines of proxy-climate evidence are the reconstructed degree day data. These suggest that Bohemia enjoys a "Central Balkan" growing season, with relative values ranging from + 250-500 degree days above 10 degrees C. Central Germany also enjoys much warmer summer conditions, with values also ranging from + 250-500 degree days. Such higher summer temperatures would have greatly extended the growing season in these same regions. Southern Poland furthermore registers values ranging from + 0-250 degree days above 10 degrees C, while South Moravian sources register consistently at + 250 degree days relative to today. The Great Hungarian Plain produces positive values of a lower magnitude, although one site from this region registers + 250 degree day conditions relative to today.

Archaeological evidence for climate change

The interpretive problems of archaeological palaeo-climate data are two-fold. First there is the question of potential cultural transformations of the environment, which may no longer be in a state of natural equilibrium, and second, there is the potentially flexible response of humans to climatic stimuli, making interpretation of such responses less-than straight-forward. Classes of evidence to be considered include the later prehistoric occupation of hydrologically-sensitive karstic areas and areas under the present-day water table.

Archaeological occupation of karstic zones

Karst in the territory of the former Czechoslovakia has been a object of investigation by both archaeologists and bio-stratigraphers. The three primary karstic zones are widely separated from each other, with the Bohemian Karst near Prague, the Moravian Karst near Brno and the Slovak Karst in the Eastern Tatras. Karst itself is comprised of largely impermeable limestone whose fissures have been subjected differential chemical weathering through by the passage of acidic ground waters. Over geologic time, land forms of high relief are produced, while underground caves are also produced by the passage of acidic ground waters. Such ground waters derive from atmospheric precipitation, thus living conditions inside karstic caves may be highly sensitive to variation in precipitation. "Drier" periods may thus be expected to see a more intensive use of caves than "wetter" periods.

The settlement of the Bohemian Karst thus appears to be cyclical, with extensive use during the periods of the Neolithic Linear Pottery Culture (cave sites=15) and Stichbandkeramik (17). These Neolithic sites often produce typical settlement material. Far fewer sites are recorded for the Lengyel IV cultural phase (2), nor do Early Eneolithic communities of the Jordanov (4) and Funnel Beaker (1) Cultures produce much evidence for the intensive use of caves. The Middle Eneolithic witnesses a resurgence in the occupation of caves (8), although no such occupations are known for the Late Eneolithic (Corded Ware and Bell Beaker Cultures). Only by the later part of the Early Bronze Age (3) do prehistoric farmers return to the caves (debris from these include tools related to textile manufacture, cf. pastoral farming). Limited use of caves continues into the Middle Bronze Age (2), although the Late Bronze Age (13) produces a mass of evidence for occupation. After an absence of evidence for the Earliest Iron Age Hallstatt C period, the

Late Hallstatt (D) period (8) witnesses the last intensive use of the caves. A final phase of cave-use occurs in the Late La Tène Iron Age (4).[48]

Archaeological occupation of inundated areas

Less equivocal archaeological evidence for oscillations in prehistoric hydrology comes from the occupational history of inundated areas.[49] This class of evidence generally refers to positive evidence for dry climate from sites below the (present day) water table. Pavúk and Bouzek cite two early horizons of low water levels evidenced by the placement of settlement features in formerly active streams, dating to the Neolithic and Eneolithic periods. From West Slovakia, Pavúk has defined these horizons as dating to the Late Neolithic Lengyel III (Budmerice) and the Middle Eneolithic (Jelšovce) periods.[50] From North-Central Europe, Bouzek has identified a Middle Eneolithic horizon only at Tetín in the Bohemian Karst.

In Saxony, a more comprehensive study of palaeo-hydrology derives from the lower terrace of the River Elbe at Dresden-Kohlmarkt (107-109 mamsl), where excavations have discovered a long and discontinuous settlement sequence on a terrace which today is subject to periodic flooding.[51] Settlement traces therefore suggest that the water table during certain periods of prehistory is relatively low.[52] The earliest traces of settlement date to the Classical Phase of the Early Bronze Age Únětice Culture and its "Übergangshorizont" to the Middle Bronze Age (Reinecke Bronze Age A2/B1). A break in the settlement is then noted until the very end of the Middle Bronze Age. The evidence for ensuing Late Bronze Age settlement is extensive, although periodic breaks in this sequence are also noted (Hallstatt B1). Hallstatt C settlement is absent, while the subsequent Late Hallstatt (D) period witnesses its return. Erratic traces from the Middle La Tène occur, in addition to more extensive finds from the Late La Tène and Early Roman Iron Ages. The coincidence of these inundation occupational phases with those of karstic cave-use is probably a product of low ratios of precipitation to evaporation.

48 Bouzek 1993a, 1993b, Sklenář and Matoušek 1994, Ložek 1980

49 Bouzek n.d., Jäger and Ložek 1982

50 J. Pavúk, Archaeological Institute at Nitra, pers. comm. Winter 1993, cf. also Pavúk 1986.

51 Gühne and Simon 1986

52 Tectonic factors in addition to hydrological changes cannot be invoked, because the slight uplift experienced in the Mittelgebirge (Starkel 1966) would be contrary to the primary bias against potential early settlement traces.

Archaeological evidence for Věteřov (Classical Early) Bronze Age climates in Moravia

The Classical Early Bronze Age optimum produces archaeological evidence for a moderately warmer climate. A modest peak in the density of lake shore settlement is noted for this time at the Bödensee, while a slightly drier phase is recorded palynologically in the decline of *Alnus* at the Swiss lakes, and in a continued rise of the Alpine tree-limit. Oxygen isotope signals from the South Polish tufa deposits are also indicative higher spring temperatures, while the valley of the Upper Vistula (et al.) undergoes a phase of erosion in its upper reaches. South Moravia also produces positive proof of warmer climate conditions with autecological faunal finds of the Věteřov Culture from Blučina-Cezavy and Hulín near Kroměříž. From Blučina come shell fragments of pond turtle whose present-day range is restricted to the Lower Danube,[53] while from Hulín come micro-fossils of the massacoral parasite *Ancylostoma duodenale*, recovered from the visceral portion of child inhumations in settlement pits of the Věteřov Culture.[54] This parasite is limited (today) to the sub-tropical parts of the Balkans, and thrives in a warm and not-too-dry environment.

Archaeological evidence for Late Bronze Age climates

An emphatic climatic oscillation occurs during the Late Bronze Age, whose archaeological remains have been associated with morphological and botanical evidence for dry and warm climate across Europe. Pedological evidence includes calcium carbonate precipitate found in rendzina palaeo-sols dated by Urnfield Culture pottery.[55] Such carbonate precipitation could occur only under conditions of high soil temperature beyond the present range, as a product of diagenesis occurring over a multi-century time-scale. These palaeosols are found at sites from the inter-mountain Poprad Basin in Central Slovakia to the Thuringian Mittelgebirge.[56] The Urnfield period also first witnesses the widespread appearance of assemblages of steppic

53 Tihelka 1960. Bogucki (1988) cites a more northerly limit of this aquatic species during the Primary Neolithic.

54 Šebela (1991) expresses doubts as to the climatic significance of these finds when compared against the longer-term pollen record. Of course, an episode of some one to two radio-carbon centuries may not have a significant impact on the woodland vegetation around such lowland sites as Mistřín and Vracov, palynological evidence to which L. Šebela ultimately defers his interpretation.

55 Jäger and Ložek 1982

56 Conceivably, a combination of both high temperature and widespread arable cultivation during the Late Bronze Age could encourage such travertine formation, with the stripping of protective plant cover from the soil surface.

gastropods in both open archaeological and cave sites in Bohemia.[57] These land-snail assemblages are "mixed", containing both thermophilous and more widely edaphic open-landscape species.[58] What is indicated by this evidence is that soil micro-climate becomes significantly drier with the Urnfield period. Notably, agriculture of the Late Bronze Age also introduces a thermophilous flora including *Vicia faba* (horse bean) and weed taxa native to the Mediterranean area.[59] This Urnfield syn-anthropic flora might reflect population movement as well as climate change. Finally, Early Urnfield finds of *Acer tartaricum* from Blučina-Cezavy in South Moravia are further indicative of hyper-continental conditions.[60]

Archaeological evidence for Early Iron Age climates

In addition to the greatly accelerated peat formation in upland Bohemia, there are numerous lines of (archaeological) evidence suggestive of wetter climes with lower summer temperatures after 800 cal. BC (cf. Fig. 16 for rates of peat accumulation in upland Bohemia).[61] For example, certain settlement features which may be associated with dry climate and are common in the Urnfield period, for example storage pits in general and wells at Berlin Lichterfelde in Brandenburg and Lovčičky in Southern Moravia, are virtually non-existant for much of the First Millennium BC.[62]

In Eastern Germany and Greater Poland, the Hallstatt C period is also marked by high-water at many low-lying fortified settlements, followed by a Hallstatt D dry episode. Thus at Lübbenau in Brandenburg, the deposition of alluvial muds over the base of Late Urnfield fortifications attests to a relatively rapid rise in the water table of some 50 cm.[63] The water table at Lübbenau recedes below modern levels by Late Hallstatt (D3) times, while a concurrent expansion of Late

57 Ložek 1964, 1972, 1980, 1981

58 Cf. Ložek (1972) for an account of finds from Srbsko in the Bohemian Karst.

59 Jäger and Ložek 1982, Willerding 1986

60 Opravil 1967

61 E.g. at the Červené Bláto mire (Jankovská 1980). A core from the Zbudov marshes in South Bohemia with four radio-carbon dates produces a similar pattern of accumulation. These assays indicate a rate of peat formation of ca. 4 cm per radio-carbon century during the Sub-Atlantic. The Sub-Boreal period prior to ca. 6-800 uncal. BC produced peat at a rate of only ca. 1 cm per radio-carbon century.

62 Willerding 1977, Moravian Museum in Brno, pers. obs. Spring 1994

63 Breddin and Buch 1969

Lusatian settlement onto what are today wetlands at Sobiejuchy, Żedowo and Biskupin in Greater Poland reflect an identical Late Hallstatt dryness.[64] The latter lake sites are then abandoned after an enduring rise of the regional water table in the La Tène Iron Age.

Review towards a test of the Climatic hypothesis

Environmental indicators considered in this chapter express later Holocene climate change at different time scales. A poorly resolved proxy-record will express only long-term tendencies, while a highly sensitive climate record may obscure long-term changes through high-amplitude secular oscillations. The proxy palaeo-climate data indicate that summer temperatures increase by *circa* four degrees C relative to today during maxima of these oscillations, while during minima, these temperatures fall to approximate present-day values, or one to two degrees C lower than those of today. The amplitude of secular agro-climatic change in Central Europe has thus been in the order of five degrees C since the Middle Holocene.

Such secular oscillations would emphatically alter the ecological conditions for prehistoric agriculture, particularly before the formal introduction of more widely edaphic crops such as spelt wheat, millet, oats and rye during the later Bronze and Iron Ages. Secular climate oscillations might also induce adaptive adjustments of subsistence systems towards optimising or mini-max modes during agro-climatic maxima and minima respectively.

Essentially, these potential agricultural adjustments are equilibrium-seeking, and may be termed "optimal farming strategies" as derived from optimal foraging theory. Optimality in this context refers to highest return rates of Kcalories per unit of labour unless population pressures or sub-optimal climates enforce the development of more labour-intensive or more risk-reducing (mini-max) agricultural regimes employing crop rotations or widely edaphic (often less-domesticated) strains. Under optimal climate conditions, mini-max subsistence strategies will thus be less productive than arable farming regimes which focus upon the most productive, if steno-edaphic crops. Under optimal agro-climates, arable farming also out-produces pastoral agriculture <u>both</u> in absolute (Kcal. per land area) and relative (Kcal. per hour of labour) terms (cf. Chapter 8). Palynologically, changes in mini-max or pastoral *vs.* optimising arable farming modes will register as a proportionate change in arable *vs.* pastoral taxa, where primary arable flora are indicative of an increasing prevalence of the optimising mode.

The precise correlation of such changes in subsistence-economic modes with specific

64 Pers. obs., 1988

archaeological cultural phases depends on the dating limits of individual pollen sites and those of the absolute chronology of the archaeologic sequence. It might be noted once again, however, that the predominant oscillatory pattern of later Holocene climate history in Central Europe is certainly one of high-amplitude, century time-scale variation (cf. Figs. 14 and 15, under dendro-chronological control). This variation can then be correlated with the seventeen secular-temporal units of settlement historical analysis of the later prehistory of Bohemia, Moravia and Slovakia to be achieved in Chapters 9-12 (see below Tables 4.2-4 and above Table 1.1).

Table 4.2. Dendro-chronology of Bödensee levels and densitio-metrics of Swiss conifers

Archaeological correlation of dendro-chronology	*Relative lake level of the* Bödensee *(dendro-chronological range)*	*Density of late season cellular growth of Swiss Alpine conifers (Δ g/cubic cm)*
Terminal Early Eneolithic	High (3100 to 3000 cal. BC)	no data
Early Řivnáč Culture	Very low (3000 to 2900 cal. BC)	no data
Řivnáč-Early Globular Amph.	High (2900 to 2800 cal. BC)	no data
Řivnáč-Late Globular Amph.	Low (2800 to 2700 cal. BC)	no data
Corded Ware to Early Únětice	High (2700 to 1750 cal. BC)	- 0.80 to + 0.04
Classical Únětice	Low (1750 to 1500 cal. BC)	+ 1.00
Middle Bronze Age	High (1500 to 1200 cal. BC)	- 1.60 to + 0.00
Urnfield cultures	Very low (1200 to 850 cal. BC)	+ 0.00 to + 1.00
Hallstatt C (Iron Age)	High (after 850 cal. BC)	no data

Table 4.3. Radio-carbon-dated Alpine, riverine and isotopic data for Central European climate

Glacial advance or ablation (alpine peat formation)	*Oscillations of Alpine timber line (relative and absolute level)*	*^{18}O fractionation of South Polish tufa (spring water temps.)*	*Upper reaches of Central European river valleys, erosion and accumulation (vegetation)*
Peat forms at 2510 m in Western Alps pre-4000 uncal. BC	Ascent of timber line to 2200 m pre-4200 uncal. BC	Rapid tufa formation (+2-3 degrees C) pre-4000 uncal. BC	Erosion of terraces (ca.) 4500-4000 uncal. BC (sub-alpine zone vegetated)
Frostnitz advance in Austrian Alps after 4200 uncal. BC	100 m depression to 2100 m after 4200 uncal. BC	Interrupted tufa build-up (cooler) 4500-3560 uncal BC	Accumulation 4000-3200 uncal. BC (sub-alpine zone de-vegetated)
	200 m ascent to 2300 m after 4000 uncal. BC	Tufa formation pre-3500 uncal. BC	
Rotmoos I advance in Swiss Alps 3350-3000 uncal. BC	200 m depression to 2100 m 3500-3300 uncal. BC	Interrupted tufa build-up (cooler than present) 3500-3000 uncal. BC	Accumulation 4200-3200 uncal. BC (sub-alpine zone de-vegetated)
	200 m ascent to 2300 m 3300-3000 uncal. BC	Tufa formation ca. 3000 uncal. BC	Erosion after 3200 uncal. BC (sub-alpine zone vegetated)
Rotmoos II advance in Swiss Alps 2850-2550 uncal. BC	200 m depression to 2100 m after 3000 uncal. BC		
	50 m ascent to 2150 m after 2800 uncal BC		Erosion pre-2400 uncal. BC (sub-alpine zone vegetated)

Table 4.3. (continued)

Glacial advance or ablation (alpine peat formation)	*Oscillations of Alpine timber line (relative and absolute level)*	*^{18}O fractionation of South Polish tufa (spring water temps.)*	*Upper reaches of Central European river valleys, erosion and accumulation (vegetation)*
		Interrupted tufa build-up (cooler) 2200-2000 uncal. BC	Accumulation 2200-1800 uncal. B.C. (sub-alpine zone de-vegetated)
		Tufa formation (+2 degrees C) 2000-1500 uncal. BC	Erosion after 1800 uncal. BC (sub-alpine zone vegetated)
Loebben advance in Swiss and Austrian Alps 1400-1200 uncal. BC	150 m depression to 2000 m 1400-1200 uncal. BC	Interrupted tufa build-up after 1500 uncal. BC (Gotland cooler)	
	150 m ascent to 2150 m before 1000 uncal. BC	Rapid tufa formation (+4 degrees C) ca. 1000 uncal. BC	Increased human impact leads to uniform accumulation of alluvium in upper reaches
Goeschner I advance in Swiss and Austrian Alps 880-320 uncal. BC	300 m depression to 1850 m after 900 uncal. BC	Interrupted tufa build-up (cooler) 700-400 uncal. BC	
Peat above pro-glacial deposits at Fernau after 100 uncal. BC	Increased human impact leads to permanent (sub-climax) depression	Tufa formation (+1-2 degrees C) ca. AD 100	

Table 4.4. Archaeological evidence for relatively drier or warmer Central European climates

Archaeological period	*Sites in Boh. Karst*	*Sites in inundated sites*	*Autecological and other data*
1. Jordanov	4		
2. Baalberg-Salzmünde	1		
3. Channeled Ware	0		
4. Řivnáč-Late Badan	8	Tetín in the Bohemian Karst, Jelšovce in Nitra Valley (W. Slovakia)	
5. Corded Ware	0		
6. Bell Beaker	0		
7. Early Únětice	0		
8. Classical Early Bronze Age	3	Occupation of inundation area at Dresden-Kohlmarkt Hulín by Kroměříž in Moravia	Pond turtle at Blučina-Cezavy and *Ancylostoma duodenale* at
9. Middle Bronze Age	2		
10. Late Bronze Age	13	Occupation of inundation areas at Lübbenau (Brand.) and Dresden-Kohlmarkt, well finds at Lovčičky and Berlin Lichterfelde (Brand.)[65]	*Vicia faba* and Mediterranean weeds introduced, steppic gastropods at Srbsko (Boh. Karst) and archaeological sites. *Acer tartaric* at Blučina-Cezavy in Moravia
11. Hallstatt C	0		
12. Hallstatt D-La Tène A	8	Occupation of inundation areas at Lübbenau (Brand.) and Dresden-Kohlmarkt	Increased steppic gastropod representation at Radovesice in Bohemia,[66] pond turtle extends into Greater Poland[67]

65 v. Müller 1964

66 Flasar n.d.

67 J. Rackham, pers. comm. at Sobiejuchy site excavations, Summer 1988

Table 4.4. (continued)

Archaeological period	*Sites in Boh. Karst*	*Sites in inundated sites*	*Autecological and other data*
13. Middle La Tène	slight traces	Slight occupation traces in inundation area at Dresden-Kohlmarkt	
14. Late La Tène	4	Occupation of inundation area at Dresden-Kohlmarkt	Increased steppic gastropod representation at Radovesice[68]
15. Early Roman	0	Well finds at Berlin-Spandau and Phöben (Brand.)[69]	
16. Late Roman	0		

68 Flasar n.d.

69 Museum für Vor- und Frühgeschichte n.d.a, Kloss 1993, cf. Willerding 1977

5. Later Holocene geo-botanical history of Central Europe

In this chapter, all secondary natural historical sources pertaining to ancient farming ecology in the Czech and Slovak Republics are reviewed. These sources include palynological, macro-botanical, faunal and geologic evidence of human land-use in the later Holocene. Adequate pollen data for lowland land-use is limited to South Moravia, which produces two excellent lacustrine sequences at Vracov and Mistřín. Of this pair, only Mistřín is well-dated for the later Holocene, while in Bohemia, limited lowland pollen sequences at Doksy and Komořany are only poorly dated. Furthermore, these Bohemian geo-botanical sites reveal little of human land-use in that their actual pollen catchments are dominated by flora from wetland and upland biomes. Other natural historical sources will prove to be more important to the lowland Bohemian situation.

Broadly speaking, three pulses of more extensive or intensive land-use are identified in the Czech and Slovak geo-botanical evidence. A minor early horizon (I) dates to the Middle Eneolithic. A major middle horizon (II) dates to the Bronze Age, although chronological differences emerge in its expression between Pannonia and Hercynia. The former (continental) zone reflects high human impact first in the Classical Early Bronze Age (Věteřov-Maďarovce), while the latter (temperate) zone reflects such impacts first in the Late Bronze Age (Urnfield period). A final significant horizon (III) of human impact is then registered in the Early Roman period. A correlation of these human impact phases with periods of maximal agro-climate should be noted at this point.

Biological evidence for human and environmental inter-action

The later Holocene history of human impact on the environment of the Czech and Slovak Republics will be traced along biological and geological lines of secondary evidence. Biological lines of evidence to be considered in this chapter include:

A. Bio-stratigraphic palynology of upland and lowland organic sediments.
B. Land snail assemblages from archaeological and karstic deposits.
C. Wood charcoal from archaeological sites.
D. Vertebrate faunal assemblages with taxa of steno-edaphic significance.

The limitations of these biologic lines of evidence include universal sampling bias and a sometimes restrictive spatial indicative value of evidence. By class of evidence these limitations are described as follows:

A. Bio-stratigraphic palynology: sites in Bohemia and Slovakia are limited largely to upland regions, (i.e.) areas untouched by prehistoric man or occupied only marginally. Only South Moravia is well served by two lowland lake sites.

B. Land-snail assemblages: spatial indicative value of individual sites is limited to local vegetation of a radius in the order of 10^{1-2} m. Because this data base is limited to archaeological sites or karstic areas (which are hydrologically sensitive), it is biased towards open landscape and sub-xeric taxa and against arboreal species.

C. Wood charcoal: macro-sub-fossil evidence of wood charcoals is most certainly indicative of the local woodland species; however, it is also highly selective evidence, as the human-woodland exploitation *per se* is reflected, rather than a representative sample of the general floral environment.

D. Vertebrate faunal assemblages: osteological remains of wild fauna in particular may be indicative of natural conditions, within the limitations posed by selective hunting practices. The accidental inclusion of avifauna in archaeological sites may be more significant of general (extra-local to regional) vegetation patterns.

Bio-stratigraphic palynological research in Bohemia (Doksy)

The review of bio-stratigraphic palynological research considers three territories: Bohemia, Moravia and Slovakia. Beginning in the Bohemian lowlands, wetland and upland floral history is represented at Doksy and Komořany in North Bohemia.

Doksy lies in a wetland area (of 250 to 270 mamsl elev.) which consists of telmatic peats formed during the Early and Middle Holocene. Early Holocene at Doksy sees a rapid replacement of *Artemisia* and *Cyperaceae* by *Pinus* and elements of the mixed-oak forest (although spectra from the nearby Mesolithic site of Hermánky are suggestive of a somewhat open local vegetation).[1] The subsequent Atlantic (Neolithic) vegetation picture completely excludes traces of human influence, rather a completely wooded environment

1 Jankovská 1992, cf. Svobodová 1986.

is indicated, in which moisture-loving species include *Alnus*, which would appear to be locally dominant, while on drier, sandier soils grow stands of *Pinus*. In the final Epi-Atlantic, stands of *Picea* replace deciduous woodlands, indicative of quite moist soil conditions, while human influence on the flora is negligible. No inferences regarding later prehistoric land-use can be made on the basis of the Doksy evidence, although somewhat limited evidence for such land-use is discernible at Komořany.

Pollen analyses at Komořany

Pollen studies in Bohemia began in the 1920's with Rudolf's analysis of (former) Lake Komořany (230 mamsl), a complete Holocene sequence which also reflects little human influence on vegetation.[2] After the last world war, a further collection of peat deposits associated with Late Neolithic, Eneolithic and Early Bronze Age pottery was made by E. Neustupný, from the southern shore of the old lake beds. Pollen analyses on these peats were subsequently conducted by V. Jankovská during the 1970's.

After Jankovská, an upland arboreal influence in the pollen spectra is dominant in the Neustupný sequence, particularly by sub-montane taxa such as *Picea*, *Fagus* and *Abies* (from the Ore Mountains), while syn-anthropic flora is barely represented. Neolithic spectra thus produce very high values of *Pinus* and very low values of N.A.P. (*Poa* and *Cyperaceae* constitute 2-3% of T.L.P.), while the lowland mixed-oak forest is only modestly represented, comprising 10-20% of T.L.P. Early Eneolithic peat deposits signify a change in the local lacustrine margin vegetation, as an alder carr develops. However, when *Alnus* is excluded, *Quercus* alone comprises 20-40%, with significant combined values of pasture and wasteland (8%). Middle Eneolithic spectra indicate more open conditions with <u>lower</u> adjusted values of *Quercus* (10-15%), while arable activity is reflected in the first cereals, along with <u>more abundant</u> pollen of pastoral and wasteland plants coincident with the reconstructed Eneolithic thermal maximum. Arable pollen <u>decreases</u> in the Late Eneolithic Corded Ware period, although traces of pastoral taxa such as *Plantago lanceolata* (1%) appear with *Artemisia*, (2%), coincident with a long-term wet period as reconstructed in Chapter 4. Arable pollen representation increases somewhat during the Early Bronze Age; otherwise, the floral spectrum is similar

2 Cf. Firbas 1952 and Neustupný 1985

to that of the Late Eneolithic.

Investigations of monolith samples PK1b and PK1d at Komořany reveal much the same sequence. Firstly, profile PK1b consists of 1.4 m of detrital lacustrine sediment of Late Glacial to Sub-Atlantic date. A succession of upland forest flora is represented sequentially by *Picea, Fagus* and *Abies*. Syn-anthropic pollen values are low, although archives indicate a proximity of ancient settlement within 500 m of PK1b.[3]

A second, shorter profile (PK1d, Fig. 19) from Komořany consists of algal gyttja of Neolithic date and alder carr peat of later prehistoric date.[4] The syn-anthropic floral succession is nearly identical to that indicated from PK1b. The first cereal pollen appears in a spectrum similar to those of Early Eneolithic date in the Neustupný sequence, although a 20 cm layer of degraded pollen in the overlying alder carr peats might reflect oxidation following from a relatively dry climate (Middle Eneolithic).[5] The renewal of favourable conditions of preservation might be inferred on the basis of pollen spectra similar to those found with the Corded Ware sherds, spectra of a pastoral aspect and lacking in cereals and annual weeds. Cereals, as well as a range of arable and pastoral weeds then return in the Early Bronze Age, after which a truncation of organic sedimentation occurs as a result of erosion during and after the Late Bronze Age thermal maximum (Fig. 19).

Pollen analyses in the South Bohemian uplands

A number of bio-stratigraphic sites are known from the uplands of South Bohemia. One group of four sites on the western slopes of the Bohemian-Moravian uplands near Chraňbož (465-85 mamsl) produces only two short sequences of Sub-Boreal date, spectra which produce no evidence of land-use; however, in the later Sub-Atlantic, trace amounts of *Humulus* and *Centaurea cyanus* from winter cultivation occur.[6]

The most-complete upland sequence from South Bohemia is that at Řežabinec (396 mamsl) in the north of the České Budějovice basin This region is known for its dramatic

3 Jankovská 1983, cf. Archive for the Parish of Komořany, Archaeological Institute in Prague.

4 Jankovská 1988a

5 Cf. Rybníčková and Rybníček 1987

6 Jankovská 1971

thermal inversions and represents the warmest area in South Bohemia.[7] The deposits here consist of 167 cm of dis-conformative organic and mineragenic sediment, with a Middle Holocene hiatus due either to periodic aeration or sedimentary erosion (regionally, the same phenomenon occurs at Zbudov and Svarcenberk).[8]

At 112 cmbs, peat-growth resumes at Řežabinec due to a rise in the local water table after the removal of local stands of *Alnus*, which reduces effective evapo-transpiration, an event dated to 1105 +/- 195 uncal. BC, or the Late Bronze Age. Replacing alder is a range of pastoral taxa, including various composites and *Rumex acetosa*. Following this pastoral land-use phase comes a regeneration of the alder carr in the Early Iron Age, above a radio-carbon assay of 800 +/- 150 uncal. BC.

Bio-stratigraphic palynological research in Moravia

The South Moravian (Pannonian) lowlands are represented by the lake sites of Vracov and Mistřín. Mistřín is well-dated (four assays) in its later Holocene aspect (Fig 20), although radio-metric dating at Vracov focuses on the early aspects of its sequence, with an ultimate assay of 1480 +/- 100 uncal. BC marking the end of the Early Bronze Age.

The site of Vracov lies at 192 mamsl, (ca.) 150 m from the eastern edge of a 19 hectare extinct lake, while only one km south lie the uplands of Chřibý (ca. 300 mamsl), a refugium for mixed-oak woodland species. Sedimentary and macro-fossil finds indicate that wet conditions prevail during the Middle Holocene, with the deposition of a detrital gyttja until Middle Sub-boreal times. During the Late Sub-Boreal however, an aquatic community of *Potomegeton* and *Nuphar luteum* is replaced by a telmatic community of *Typha latifolia* on a calcareous clay, indicative of a major drop in the water table. After this terminal Sub-Boreal (ca. 1000 +/- 300 uncal. BC) dryness, the subsequent Sub-Atlantic brings increased wetness with the formation of peat and gyttja deposits and local telmatic to fully aquatic *Carex*, *Potomegeton* and *Nymphaea* floral communities.

7 Rybníčková and Rybníček 1985

8 Cf. Rybníčková and Rybníček 1987, Rybníček 1989, Rybníčková and Rybníček 1968 and Rybníčková et al. 1975.

Pollen analyses at Vracov

Vracov's palynology indicates that the regional flora of the Neolithic consists of a climax mixed-oak forest consisting of *Quercus*, *Ulmus*, *Tilia* and *Carpinus*, with a minor admixture of (archaeo-phytic?) *Artemisia* (ca. 5% of T.L.P.) and *Silene* (ca. 2%). With the Neolithic, the first trace of agriculture appears in *Secale cerealia* (probably an arable weed rather than a cultivar). This isolate accompanies the absolute (Holocene) limit of *Chenopodium*, a fall in *Ulmus* and *Tilia*, as well the establishment of the rational limit of *Carpinus* pollen, a succession suggestive of human influence on forest composition. With the end of this early cultivation episode, a distinct rise in *Urtica* (to 10%) is discernible. Most likely, this nitrophilous plant is colonising abandoned fields.

After a break in agricultural occupation during the Early Eneolithic, the <u>Middle</u> Eneolithic Jevišovice Culture sees the return of syn-anthropic flora, with the appearance of true cereal grains, waste-ground species of the genus *Centaurea*, as well as the establishment of the rational limit of anemophilous *Chenopodium*. The pollen curves of steppic indicators remain unperturbed at this time.

Subsequent strata (of an interpolated date of ca. 2000 uncal. BC) contain no cereal pollen, although waste-ground and weed taxa continue to be represented. The latter floral assemblage is attributable to the Late Eneolithic (Corded Ware to Bell Beaker Culture). Associated with the fourth assay is a (Věteřov Bronze Age) rise in cereal pollen to 2.0%. The agricultural significance of this event is underlined by an emphatic decline in the low-lying alluvial forest of *Alnus* and *Picea*.[9]

Direct traces of cultivation fade away during the course of the Bronze Age, although pollen registration of pastoral, ruderal and arable weeds remain significant (ca. 5%). Intensive cultivation resumes during the latest part of the first millennium BC, as represented by cereals and arable, pastoral and ruderal weeds.[10]

Pollen analyses at Mistřín and Kameníčna in South Moravia and West Slovakia

Mistřín in Southeast Moravia is situated at 175 mamsl in the district of Hodonín, where

9 Cf. Opravil 1967

10 Rybníčková and Rybníček 1972

a 235 cm sequence of detrital gyttja and telmatic peats has been subjected to pollen analysis (Fig. 20). As indicated by five radio-carbon dates, its pre- and proto-historic sequence spans the Neolithic until the Early Slavonic period. It is significant that A.P. is dominated by an alluvial woodland consisting of *Alnus* and *Picea*, while values of steppic taxa such as *Artemisia* and *Poa* are greater here than at Vracov due to differences of elevation and relief. Mistřín's Sub-boreal sequence produces a relative peak (0.8%) in cereal pollen occurring during the Middle Eneolithic period, followed by a waning of syn-anthropic taxa and a waxing of *Alnus* during the Late Eneolithic. These events are dated by consecutive assays of 2650 +/- 65 and 2150 +/- 60 uncal. BC. Phenomena culminating in a stratum dating to 1420 +/- 60 uncal. BC include an emphatic decline of *Alnus* and an increase in a wide variety of syn-anthropic taxa including *Cerealia* at 2.5%, *Centaurea*, *Rumex acetosella*, *Plantago major-media* and *Plantago lanceolata*. These taxa reflect an intensive use of the alluvial forest zone during the Věteřov Bronze Age. After a decline of syn-anthropic taxa in the Middle Bronze Age, cultivation rises in the Late Bronze Age, followed by a further decline during the Early Iron Age, with the rise of *Alnus*. Sporadic cultivation occurs during the Iron Age, although a return to rational cultivation is indicated in the Early Roman Iron Age (ca.) 140 +/- 70 uncal. AD.

Additionally in West Slovakia, an alluvial pollen site of Kameníčna (120 mamsl) derives from a Danubian inundation area. The Neolithic age begins at (ca.) 265 cm, after relative zonal dating, spectra which reveal a mixed-oak forest with pine, while during the inferred Bronze Age period, a decline in the mixed-oak woodland is registered at 145 cm, attended by an increase in N.A.P. to values of over 60%. (cf. Věteřov period above).[11] Tree pollen never recovers to its pre-145 cm levels at Kameníčna.

In short, the lake sites of Vracov-Mistřín in lowland South Moravia exhibit three in-phase pulses of enhanced cultivation in the Middle Eneolithic, the Věteřov and Early Roman periods. Deforestation in the geo-botanical sequence at Kameníčna also affirms the South Moravian Věteřov pattern within the chronologic empirical limits of this site.

Land snail assemblages from the Czech and Slovak Republics

Analyses of terrestrial gastropods of the later Holocene have focused on stratified

11 Krippel 1986

Karstic cave sites and sub-surface archaeological deposits at open sites. These studies are universally indicative of periodic Bronze Age dryness.

From the Bohemian Karst west of Prague, land snail assemblages have been examined at scree-slopes and carbonate deposits to be found in association with prehistoric pottery sherds.[12] The first indications of a regularly open, steppic landscape comes from gastropods at Srbsko from the Late Bronze Age,[13] while in the Carpathian Basin, a more precocious tendency is observable in the Slovak Karst, where the formation of the steppe is already under way in the period of the Middle Neolithic Bükk Culture.[14] Gastropods from Late Bronze Age occupations in the Slovak Karst also witness an acceleration of a one-way process of deforestation. Hypothetically, once moisture-retaining soils are degraded and the shielding effects of forest removed, a meta-stable condition in the flora is realised, vectors which inhibit recolonisation by woodland taxa.

Land snail analyses from of archaeological sites in Bohemia derive primarily from zones of degraded czernozems in the Elbe (Labe) lowlands. The Late Bronze Age period produces the first widespread evidence for the appearance of steppic land snails, presumably in the pastures and fields used by Urnfield farmers.[15] Predating this (Knovíz) Bohemian "steppic horizon" are similar finds (e.g. *Euomphalia strigella*) from the Early Bronze Age of Moravia at Blučina-Cezavy,[16] while a mix of open and closed landscape gastropod species has also been recovered from the trans-Iron Age site of Radovesice 23 in North Bohemia, where the earlier Iron Age period is dominated by the wet meadow species *Bradybaena fruticum* (comprising 87.5% of the assemblage).[17]

Dry pasture taxa (*Helicopsis striata* and *Capea vindobonensis*) then increase at Radovesice 23 in the La Tène A period. Finally, in the Middle La Tène, *Bradybaena fruticum* recovers to its Hallstatt C-D levels, whilst the range of steppic taxa narrows from four to two, tendencies also suggestive of wetter local conditions.

12 Ložek 1964, 1972

13 Cf. Sklenář and Matoušek 1994

14 Ložek 1980, 1986

15 Ložek 1964

16 Flassar 1990

17 Flassar n.d.

Wood charcoal from the Lužický potok basin in Northwest Bohemia

Macro-sub-fossil evidence from archaeological sites represents the human selection of woodland species for the purposes of construction or fuel-use. The longest sequence of finds from a single region comes from the Lužický potok basin in Northwest Bohemia, where analyses by Kyncl of seven sites encompass a time-span from the Neolithic until the Roman Iron Age (cf. Fig. 2).[18] Primary Neolithic and Early Eneolithic exploitation seems to have occurred within the context of a mixed-oak woodland, although by the Late Eneolithic, an expanded use of (telecratic) *Carpinus betulus* and wetland *Alnus glutinosa* is discernible. Woodlands of poor acidic soils are then first exploited during the Knovíz period, when secondary woodland traces (as reflected in *Betula*) also appear. After the Late Bronze Age, a mesic interval is indicated in the Early Iron Age Bylany Culture at Vrchnice, the sole assemblage in which *Alnus* is dominant (cf. Fig. 3).

Vertebrate faunal assemblages from archaeological sites

Independent of floral evidence, environmental conditions can be discerned after faunal data from archaeological sites. Beginning in the Neolithic, the site of Chotěbudice in Northwest Bohemia has produced numerous wild animal specimens reflecting a wooded environment, as well as a single fragment of wild horse, whose presence suggests its attraction to the clearings made by early farmers.[19] The notion that small patches of open landscape persisted in the Middle Holocene mixed-oak woodland finds further support in South Polish evidence, where micro-fauna (rodents and birds) at Neolithic cave sites include taxa adapted to open woodlands.[20] However, avifaunal assemblages from Neolithic and Eneolithic sites in Bohemia and Moravia are dominated by closed woodland species, with exception of *Accipter nisus* and *Lyrurus tetrix* which inhabit more open woodlands. Importantly, the first steppic bird species (*Otis tarda*) appears in the former Czechoslovakia at the end of the Early Bronze Age, at Nitriansky Hrádok in Southwest Slovakia. In respect to the latter find, it is also significant that remains of

18 Kyncl 1987a, 1987b

19 Cf. Peške 1991

20 Kruk 1980

hunted animals from graves of the somewhat earlier Nitra Culture in the same region yield small quantities of rabbit bone, a taxon indicative of rather open landscapes, along with woodland taxa such as deer and bear.[21] This hypothetical (culture-) steppification extends to Bohemia by the Late Bronze Age, when avifauna finds of *Perdix perdix* and *Asio flammeus* appear at Lomažice and Bláhotice.

This appearance of steppic species distribution in the locus of prehistoric settlement may be understood as an effect of the expansion of the cultural environment with growing human populations. Generally, a largely wooded environment is indicated in prehistoric faunal assemblages, with significant clearings first emerging in the Mad'arovce-Věteřov period in Pannonia, and then in the Knovíz period in Bohemia.

Modern and Late Holocene pedogenic processes

Patterns of modern and palaeo-soil distribution relative to prehistoric settlement in Central Europe are further indicative of human impact on natural processes. In this work, a general contrast is made between the more temperate regions of Hercynia, and the regions in the continental zone of Pannonia.[22] The present-day soils of lowland Bohemia are principally of the brown-earth or cambisol-type, characterised by moderate amounts of leaching and an over-lying un-decomposed humus horizon.

Cambisols are particularly significant in Northwest Bohemia, although the warmest regions (e.g. Podbořany) are covered by haplic phaeozems, which in places overlie limestone substrata (the C-horizon here will contain significant quantities of calcareous clay). At a micro-regional scale, patches of mollisols (or "czernozems") are identified, usually in <u>association</u> with prehistoric settlement.[23]

In contrast to Northwest Bohemia, Central Bohemia is richer in (haplic) czernozem coverage, although moisture-sensitive arenosols, stony luvisols and brown-earths or cambisols also appear. Significantly, the distribution of czernozems and arenosols lies in the hottest regions of Bohemia, with the former also highly correlated to areas of

21 Cf. Peške 1981 and Bátora 1994

22 UNESCO 1981

23 Cf. Smrž 1994, Waldhauser 1984b

prehistoric settlement on the Ceský Brod.[24] Ancient farmers would appear to have avoided the dry arenosols, however. A combination of agricultural and climatic factors might account for aspects of czernozem distribution, with the clearing of woodland and the creation of a cultural steppe enhancing vectors which encourage its development (these include increased moisture stress, reduced decomposition of humus-matter and reduced leaching). In contrast, the basins of South Bohemia provide only marginal agricultural land, primarily on gleyic luvisols developed on alluvial outwash silts.

Pannonia presents a quite different pattern of soil development. Beginning in South Moravia, an extensive coverage by haplic czernozems occurs in areas enjoying less than 600 mm of precipitation *per annum* today. These low lying areas are flanked by orthic luvisols (including "para-brown earths") which develop at higher elevations under higher rates of precipitation (of ca. 700 mm *per annum*).

Southwest Slovakia is complex in its soil coverage, due to the proximity of the Danube to the south, and the abutment of the Tatras to the north. Close to the Danube, soils are generally subject to extreme-moisture stress, for example, the cambic arenosols developed on Pleistocene sands. Other course-textured soils in Danubia such as the calcic fluvisols require irrigation for arable farming. Also influenced by geology and drainage are the soils found at the foothills of the Tatras and higher terraces of the middle reaches of the tributaries to the Danube. In low-lying areas lie (calcic) czernozems, often associated with prehistoric settlement during moist climate phases,[25] while in areas of higher orographic precipitation lie the brown-earths and para-brown earths, of which the latter enjoy greater moisture retention than the low-lying czernozems. Although less-fertile than czernozems, para-brown earths are favoured by ancient farmers during phases of moisture-stress.

Later Holocene geomorphological history of the Czech and Slovak Republics

Later Holocene geomorphological history will be considered here with respect to its relationship to vegetation history, considered along two lines of inquiry:

A. The history of czernozem formation and its significance to steppic history.

24 Cf. Rulf 1983

25 Cf. Bátora 1995, Pavúk et al. n.d.

B. The history of soil erosion as initiated by deforestation and agriculture.

On the basis of these dual lines of evidence, it will be proposed that human impact on soil formation and erosion first becomes significant in the Bronze Age, with registered impacts first occurring during the Classical Early Bronze Age (Maďarovce-Věteřov) period in Pannonia, and then in the Late Bronze Age period of Bohemia.

The development of czernozems and their relevance to prehistoric vegetation

The positive relationship between the distribution of steppe and that of czernozem soils has implications for the historic development of Holocene flora. No observations have been made regarding the rate of czernozem formation, although data exist as to their relative rate of degradation. From the Great Plains, tree plantations in Illinois overlying former mollisols have induced a quartering of the available A-horizon humus matter, with leaching leading to the formation of an emergent B-horizon during a 75 year period.[26] Similar phenomena are also observable on the North Pontic steppes, where a tree plantation near Mauripol north of the Sea of Azov has induced the leaching of bases from the upper 110 cm of the remaining A-horizon, with a diagenic formation of carbonates as deep as 150 cm.[27] One wonders if soil preparation by prehistoric farmers might also induce aeration and reduce bacteriological activity necessary for the break-down of humus substance. Within the context of this hypothesis, one might also imagine that woodland clearance in hotter and drier areas might alter the water-balance sufficiently to reduce leaching, producing on brown-forest soils the factors leading to black-earth formation. This hypothesis finds support in the Nitra Culture cemetery site of Jelšovce in Southwest Slovakia, where grave-fills of the Earliest Bronze Age are comprised of brown-earths. Within two centuries, grave-fills of the Mad'arovce Culture are comprised of black-earths like those of the present soil cover.[28]

If one accepts that incipient czernozem formation and degradation can occur over one to two centuries, its pattern of distribution throughout Central Europe becomes

26 Bunting 1965

27 Wilhemy 1950

28 J. Bátora pers. comm., Winter 1995

understandable. With the presence of high-humus czernozems limited in their westward distribution to the Northwest Carpathian Basin and Upper Silesia, it is apparent that the primary control on czernozem formation stems from the degree of climatic continentality. Further west, degraded czernozems of much-lower organic content are encountered, often containing as little as 2% humus matter (see note).[29] Given the lower degrees of humification and thin A-horizons of the degraded czernozems, it is possible that human alteration of the soil micro-climate has led to their czernozem-like formation.

The geographic relationship between soils and settlement in the more continental parts of East-Central Europe is subtly different. Here the farmers are not invariably attracted to the czernozem zone, rather poorer soils (e.g. para-brown earths) enjoying greater moisture retention and a higher orographic situation are periodically preferred, suggestive of an intent to reduce moisture stress (cf. Figs. 105-7).

Later Holocene history of soil erosion and deposition

Prior to the deposition of later Holocene sediments, there must first be erosion. Such sedimentary erosion is dependent on (1) soil exposure, (2) precipitation and (3) gravity, factors which are now described. Whether by natural vegetational succession or human intervention, whenever substantial tracts of land are exposed without substantial root-structures holding-together the over-lying A-horizon, soil erosion is enabled. Once hand-cultivation by hoe and mattock is replaced by the traction-ard (or plough), soil structures are made still-more friable and liable to be eroded-away *via* water transport.[30]

Through precipitation, the water transport of friable soil particles (primarily silts) occurs whenever the threshold-ability of surface soil to absorb water is transgressed, or when rainfall intensity is particularly great, through Hortonian overland flow. Such erosion is experienced initially as sheet-wash, (i.e.) the relatively even distribution of erosion over a planar area, which becomes subsequently concentrated along rills and then gullies.

Wherever slopes or terrace-edges are encountered, gravity will encourage soil creep and mass-movement, even in the absence of extensive soil exposure and intensive precipitation. Such processes may-then be regarded as a potential source of sediment

29 Note that Tárabek (1971) cites assays of Early Holocene date from (palaeosol) czernozem humates in eastern parts of the former Czechoslovakia, suggesting that some steppification has proceeded prior to the Middle Holocene maximal aforestation along the northern rim of the Carpathian Basin.

30 Butzer 1982, Selby 1985

even in the absence of substantial human impact.

Two varieties of depositional environments are considered in this context: alluvium and colluvium.

Alluvial deposition reflects regionally significant patterns of erosion and deposition, as material is generally derived from up-stream sources whose deposition is subject to the reduced competence of the fluvial system to carry sediment in site-specific contexts. The relative significance of cultural impacts in this context is inversely proportional to the energy-level of the fluvial system. Large-scale systems such as the Danube or Elbe can be expected to experience a "natural background-level" of erosion and accumulation of sediment, with an increased sediment load from enhanced by agricultural activity leading eventually to greater sediment accumulation. Sediment accumulation in "medial" fluvial systems such as the Ohře or Nitra might be expected then to respond proportionally more to human activity, while sediment supply in stream or creek environments might be dependent almost entirely on agricultural activity where woodland is the climax vegetation-type. Importantly, agricultural disturbance enhances alluviation potential by increasing potential sediment supply by a factor of 200.[31]

Colluvial deposition will not be considered in great detail here as its significance is purely local, reflecting primarily the factor of gravity. It should also be considered that rapid soil accumulation at colluvial foot-slopes has been documented in a well-dated sequence by Butzer at the Archaic Native American base-camp at Koster, Illinois, where rates of accumulation of up to 50 cm per century are reconstructed in a locally-disturbed wooded environment.[32]

Within these parameters, erosion and accumulation can be expected then to be most-significant during periods of more intensive arable (ard or plough) agriculture, or more intensive precipitation. In the historic example of the Sporer Minimum (ca. AD 1250) in the Lower Ohře Valley, thick deposits of flood-loams completely bury at least five High Medieval villages during this period of increased precipitation and intensive agricultural settlement (i.e., with highly exposed soil surfaces).[33]

31 Shelby (1985) cites U.S. Dept. of Agriculture data, which attest to mean woodland erosion rates of ca. 8.5 tonnes/km^2 per annum, while arable farmland erosional rates of ca. 1700 tonnes/km^2 per annum are attested.

32 Butzer 1977

33 Kotyza 1991

Later Holocene alluvial and colluvial deposition in Bohemia

The earliest evidence for alluvial deposition in Bohemia comes from Borek on the Elbe, where Middle Holocene conditions produce a background level of aggradation in its beds in spite of a regional vegetation which consists of extensive woodlands of restricted soil exposure. Notably, a Late Michelsberg site (providing a maximum limiting date of 2900 to 2800 uncal. BC) lies preserved under three metres of flood-loam alluvium at Borek, although more intensive accumulation is recorded as slightly older than 700 to 300 uncal. BC, (i.e.) of later Bronze Age or earlier Iron Age date.[34] Along similar lines, one layer of Early Bronze Age sherds at České-Budějovice in South Bohemia is also buried by 115 cm of fine-grained (silt?) sediment. The latter alluvium could have been deposited at any time during or after the Early Bronze Age, when South Bohemia witnesses an increased intensity of agricultural settlement after a general abandonment of settlement during the Late Eneolithic period. Also at Kostolec nad Ohří in Northwest Bohemia, a dune site of Late Bronze Age date is covered by alluvium during the Štítary Urnfield period.[35]

Notably, the Late Bronze Age produces the first widespread indications of alluvial deposition. Observations by P. Čech at Konobrže in Northwest Bohemia bear witness to the deposition of substantial Late Bronze Age alluvial sediment with Knovíz ceramics at the bottom of a stream profile preserved to a depth of (ca.) 1.5 m (after the removal of over-burden). Also at Radovesice 23 in the Middle Bílina valley, two distinct layers of accumulation with pottery sherds are identified in the adjacent profile from Lukovský potok. The lower sherd zone contains Late Bronze Age (Lusatian Urnfield) material, while the upper zone produces Early Roman pottery.[36] Further incidents of Roman Iron Age alluvial accumulation are recorded at Milžany in the Lužice basin of Northwest Bohemia, where an Early Roman settlement pottery is deposited in flood-loams prior to their development into soils.[37]

It is likely that colluvial processes are ubiquitous, although event horizons may be

34 Dresslerová 1995b.

35 Beneš n.d., cf. Beneš 1995, Butler n.d., Zvelebil n.d.

36 Waldhauser et al. 1993

37 Neustupný 1987

discerned.[38] However, a gravel-colluvium described by Ložek near Litoměřice in Northwest Bohemia is indicative of much stronger erosional vectors than those cited above. The scree slope at the base of the terrace near Litoměřice cannot have been produced by mere mass movement. Rather, agricultural activities are invoked, dated by pottery of the Late Bronze Age Lusatian Culture (cf. Horizon II below and Note 38).[39]

Later Holocene eolian and alluvial deposition in Moravia

The Holocene geologic history of the Morava River catchment has been extensively studied by Havlíček. Beginning with the Early Holocene, deposits of wind-blown sediment dated by Mesolithic flints in the South Moravian valleys of the Dyje near Dolní Veštonice and the Morava near Mikulčice-Na Válech attest to a certain level of relict steppification in the earlier Holocene. It is also apparent from sections of these sand-dunes that erosion and redeposition of eolian sands has taken place subsequent to the Mesolithic. Such wind-borne "sands" could have originated primarily in a more open (forest- or culture-steppe) environment. The dating of these secondary eolian deposits is uncertain, although accumulation can be demonstrated after the Seventh Century AD Early Slavonic Period. Earlier (secondary) eolian deposition is not excluded.[40]

Extensive evidence for later Holocene alluvial accumulation in the Morava River valley predates that of Bohemia, with radio-metrically dated alluvium being laid-down first in the Early Bronze Age. As established by radio-carbon assays, the first extensive later Holocene flood-loams are deposited at Dolní Veštonice on the River Dyje in South Moravia at 1720 +/- 60 uncal. BC, while in the Upper Morava valley by Veselí nad Moravou in North Moravia, similar deposition occurs after 1560 +/- 130 uncal. BC.[41] Further Morava flood-loams are associated with pottery of the Late Bronze Age near Uherské Hradiště-Staré Město, where Lusatian ceramics were found in flood-loams deposited at a depth of six to seven metres below the present-day flood plain surface, atop

38 E.g., colluvial deposits at Velký Hůbenov, Poplže and Pavlov in Bohemia and Moravia are of Late Bronze Age (cf. Horizon II below), Late Iron Age (cf. Horizon III below) and High Medieval date (cf. Butzer 1982 and Smolníková and Ložek 1973).

39 Jäger and Ložek 1982

40 Havlíček and Kovandá 1985, Rybníček 1989, Havlíček 1983

41 Havlíček 1987

lag gravels. Further evidence for Bronze Age erosion and alluvial deposition comes from Lanžhot in South Moravia, where alluvial deposits yielded a broad assay of 1230 +/- 330 uncal. BC.

The Roman Iron Age in Moravia also produces extensive evidence of erosion and alluvial deposition. For example at Polešovice in South Moravia, ceramics of the Late La Tène Culture (D) occur at the base of flood-loams of the River Morava, while flood-loams of a depth of 3.7-4.0 m at Strážnice also contain wood charcoal yielding an assay of 10 +/- 90 uncal. AD (of Early Roman date). Further north at Kvašice, deposition of flood-loam at the margin of the River Morava is also initiated after 85 +/- 80 uncal. BC, a date statistically equivalent to that from Strážnice. A potential association of alluvial deposition with periods of more intensive agricultural settlement is borne-out in Early Modern developments where relative population levels are more readily reconstructed. During the Thirty Years War (1618-48) for example, the population of Bohemia and Moravia is thought to have fallen by as much as 30%. A concurrent horizon of soil formation on the (consequently) stable flood-loam surfaces of the Morava River valley is also discernible which dates after artifacts from the Middle 17th Century.

Late Bronze Age Karren formation in the Slovak Karst

Soil erosion in the Slovak Karst is indicated by a horizon of lapie or Karren formation, dated *via* pottery to the Late Bronze Age. The latter features are formed through chemical weathering of carbonates with precipitation, a process encouraged by the removal of soil cover and the increased availability of organic carbon dioxide.[42] This Late Bronze Age formation horizon takes place against a general Holocene tendency towards Karren degradation and dissection by ice-action.[43]

Review of Bohemian evidence of human impact on the environment

The later prehistoric period in Bohemia witnesses at least three discernible horizons of greater settlement intensity after human environmental impact registered through geo-

42 Jäger and Ložek 1982

43 Cf. Starkel 1966

botanical data bases. The first (minor) phase (I) may date subsequent to the Terminal Michelsberg (Phase V), or Middle Eneolithic, with the accumulation of flood-loams at Borek. This period is also broadly contemporary with the first appearance of cereals at Komořany (in the Neustupný sequence). A sedimentary hiatus at Komořany PK1d might also be attributable to warm, dry conditions of Middle Eneolithic date (Fig. 19).

A second (major) phase (II) of intensive erosion and accumulation dates to the Late Bronze Age, as reflected in flood-loams at Kostolec nad Ohří, Konobrže and Radovesice 23, coeval with scree slope accumulation at Litoměřice (in North Bohemia). Steppic gastropods at Srbsko and a clutch of Knovíz Urnfield sites of this "horizon" should be noted in tandem with the appearance of steppic avifaunal species at Lomažice and Bláhotice. As steppe indicators increase, wood charcoal finds from Lužický potok are also suggestive of the exploitation of more marginal, sub-xeric woodland environments. The appearance of secondary woodland species is similarly suggestive of a reduction of the pristine, climax forests. This phase of extensive lowland land-use concurs with upland pollen evidence for pastoral agriculture at Řežabinec in South Bohemia. Fortuitously, the clearance of alder and a subsequent anthropogenic rise in the water table at Řežabinec allowed for the continuation of organic sedimentation. However, the organic sedimentation at the lowland pollen site of Komořany PK1d is truncated at this time, reflecting a return to warm, dry conditions.

A final phase (III) of extensive land-use can be discerned during the Early Roman period. Erosion and accumulation at Milžany dates from this time, as does the upper accumulation deposit at Lukovský potok by Radovesice 23. Secondary cultivation indicators (*Centaurea cyanus*, usually found with *Secale cerealia*) also appear at the Southeast Bohemian upland site of Chraňbož, indicative of a further phase of upland arable agricultural land-use.

Linkage of these three phases with optimal agro-climatic periods is suggested. Compared to modern conditions, summer temperature are reconstructed at +1-2 degrees C for Phases I and III, while (emphatic) Phase II is linked with summer temperatures of a +2-4 degrees C differential. Potential arable recessionary intervals are reflected in an absence of evidence at morphological sites, although pollen spectra in South Moravia and South Bohemia are positively suggestive of relaxed syn-anthropic influence on the vegetation during the Late Eneolithic, Middle Bronze Age and the Early Iron Age.

Notably, wood charcoal assemblages from Lužický potok also exhibit an unusual alder prominence during the Corded Ware period, and a unique alder dominance during the period of the Bylany Culture, suggestive of cooler and wetter conditions. Finds of a minor alluvial woodland component at the Hallstatt B1 site of Přezetice are also suggestive of minor interruption of warm, dry conditions of the Late Bronze Age. Also reflecting cooler and wetter conditions, the Pre-Roman Iron Age witnesses a general acceleration of organic sedimentation at upland bio-stratigraphic sites in South Bohemia.

Review of Pannonian evidence of human impact on the environment

The later prehistoric period in Moravia and Slovakia also witnesses at least three discernible horizons of increased human impact on the environment, as reflected in bio-stratigraphic and geomorphic data bases. The first phase (I) dates to the Middle Eneolithic, is reflected in an early syn-anthropic pollen maxima (*Cerealia* up to 1%) at the lacustrine sites of Vracov and Mistřín (Fig. 20).

A second, more emphatic phase (II) of extensive land-use occurs during the Bronze Age, although after the dating of flood-loam deposits at Dolní Věstonice, Veselí nad Moravou (and?) Lanžhot (in the Morava River catchment), the initiation of this phase is coeval with the the terminus of the <u>Early</u> Bronze Age. A precocious steppic development is further affirmed in gastropod finds from Classical Early Bronze Age contexts at Blučina-Cezavy in South Moravia, and *Otis tarda* avifaunal material in Mad'arovce contexts at Nitriansky Hrádok in Southwest Slovakia. Similarly, the development of czernozems at the interface of the Nitra and Mad'arovce Cultures at Jelšovce provides further evidence for deforestation and steppe formation. Importantly, both Mistřín and Vracov register significant peaks (2+%) of cereal pollen at this time, in tandem with reduced values of alluvial woodland pollen. Further de-vegetation in the uplands is indicated by an Urnfield Bronze Age horizon of Karren formation in the Slovak Karst. Notably, this inferred Bronze Age phase (II) of higher human impact in the Western Carpathian Basin is also coeval with a palynologically reconstructed period of localised agricultural impact on wooded steppe environments in the Tisza Valley in the more continental eastern aspect of the Hungarian Plain.[44]

A final phase (III) of extensive land-use can be discerned during the Early Roman period. Flood-loams from Strážnice, Kvašice and Polešovice form a relatively coherent horizon ending around the time of the Marcomannic Wars of Rome. Pollen evidence concurs with that of alluvial geomorphology in moderately higher primary cultivation values (1+%) attained during this period.

A significant difference in the chronological expression of "Phase II" emerges in Pannonia, in the clustering of syn-anthropic impact earlier in the Bronze Age sequence. Possibly reflecting the differential limiting factors on agriculture in the drier Pannonian province, moderately warmer climates here produce the strongest syn-anthropic response in the floral and morphological data bases, although potentially, flood-loam initiation at České Budějovice in South Bohemia might also date to this earlier Bronze Age period.

Altogether, the later Holocene geo-botanical record supports the Central European Climatic hypothesis as formulated in Chapter 2. Syn-anthropic indicators as defined by vectors such as soil erosion, sub-xeric pedogenesis, secondary woodland formation (after wood charcoal), steppe formation (after gastropods and avifauna) and human land-use (as defined palynologically at upland Bohemian and lowland Moravian pollen sites) align significantly with favourable agro-climates. Differences in the periodicity of the major Bronze Age horizon (II) of human impact in Hercynia *vs.* Pannonia also affirm the Climatic hypothesis in that this syncopated relationship reflects differences in the limiting factors on agriculture between these two zones. In Chapters 9-12, reconstructions of maximal phases of agricultural settlement during the later Holocene will also align significantly with Horizons I-III above.

44 Willis et al. 1998

6. Primary Hercynian geo-botanical sites

Primary Hercynian pollen sites (Fig. 17) are indicative a climax vegetation of mixed-oak woodland at stable equilibrium, capable of complete regeneration at 10^{1-2} year time-scales in the absence of human impact. Pre-Neolithic woodlands are dominated by *Tilia* and *Ulmus* in the lowland locale of Bylany 1 (East Bohemia), while *Tilia* is still dominant in the Eneolithic forest, after limited local data from Konobrže (Northwest Bohemia). Originating in the Ore Mountains, *Pinus*, *Picea*, *Abies* and *Fagus* at Komořany (Northwest Bohemia) colonise lower elevations in the later Holocene. Bronze and Iron Age forests are comprised of *Quercus*, and increasingly, *Fagus* in the basins of Vranský and Vinořský potok (in Northwest and Central Bohemia).

With the expansion of primary cultivation, deforestation generally ensues, particularly during the Late Bronze Age and Early Roman periods. Some variability is indicated in the long duration of the Late Bronze Age sequence at Vranský potok, with a major phase of aforestation occurring at the transition from the Knovíz to Štítary stages of the Urnfield period (ca. 1100-1000 cal. BC). Latest (Štítary) Bronze Age weed assemblages at Vranský potok are also suggestive of a limited winter cultivation. The latter arable regime becomes more discernible during the pre-Roman and Roman Iron Ages, when such practice might be viewed as a means of distributing the risk of crop failure, due to differences of ecology between spring and winter plantings. Apparently, winter cultivation becomes dominant in Early Slavonic agriculture.

Characteristics of six primary sites from the Hercynian zone are now summarised as follows:

1. Komořany Lake in Northwest Bohemia: a Holocene lacustrine sequence (without independent chrono-metric controls, Figs. 21-23).
2. Bylany 1 in East Bohemia: an abbreviated Late Glacial to Early Holocene alluvial sequence from a first order drainage (also lacking in independent chrono-metric controls, Figs. 24-26).
3. Konobrže in Northwest Bohemia: an Eneolithic and Bronze Age archaeological site (dated *via* ceramic chronology, Figs. 27-30).
4. Vranský potok in Northwest Bohemia: a later Holocene alluvial sequence from a second order drainage (principal site, with three radio-carbon dates, Figs. 31-45 and back jacket).

5. Vinoř in Central Bohemia: an Early Iron Age archaeological site (dated *via* ceramic chronology, Figs. 46-50).
6. Vinořský potok in Central Bohemia: an intermittent later Holocene (?) alluvial sequence from an eighth order drainage (without independent chrono-metric controls, Figs. 46 and 51).

Komořany Lake

Lake sediments at Komořany (228 m a.m.s.l.) in the Brown-Coal Region of Northwest Bohemia were first investigated by Rudolf, Firbas and Losert before the last world war, and subsequently by Jankovská and the present author. The south bank of the former lake is reported by Machleidt to contain concentrations of prehistoric settlements from the Neolithic and later periods.[1] The exposure to be described comes from the "Mine of the Czechoslovak Army", and was encountered during a tour of the open-cast mine with Z. Smrž at a locality (ca.) 500 m north of the Machleidt-indicated find-spots. These sediments were preserved under a road servicing the open-cast mine from which an 80 cm monolith was retrieved (Fig. 21).

Sediments at Komořany consist of a lower 56 cm of stratified algal gyttja and a middle layer of 13 cm of weakly-stratified detrital gyttja, capped by 11 cm of turfa peat with ligneous detritus (soft wood, probably of alder, cf. Fig. 22). All three layers were sampled for pollen, although pollen degradation in the (upper) turfa peat was too great to allow for reliable counts (although *Alnus* was dominant amongst the degraded grains identified). The lower spectra will now be described as a simple percentage of T.L.P. (Fig. 23).

Spectra from the algal gyttja at 78, 50 and 36 cms span the Early to Middle Holocene, after the pollen zonation of Firbas.[2] The spectrum at 78 cm proved to be Pre-Boreal (P.A.Z. IV) in date, with an assemblage dominated by a park land vegetation consisting of *Pinus* (58.8%) and *Betula* (31.7%). Non-tree pollen is weakly (5.4%) represented by *Gramineae*, *Artemisia* and *Caryophyllaceae*. The spectrum at 50 cm proved to be of Boreal (P.A.Z. V) date, with the gradual replacement of *Pinus* (35.6%) and *Betula* (8.0%) by *Corylus* (32.4%) and *Alnus* (5.1%). The mixed-oak forest also develops at this time, represented by pollen of *Quercus* (7.6%), *Ulmus* (5.5%) and *Tilia* (2.2%), while N.A.P. is barely represented (2.9%). The spectrum at 36

1 Archival records of the Katastr of Komořany in the Archaeological Institute, Prague.

2 Firbas 1949, 1952

cm proved to be Early Atlantic (P.A.Z. VI) in date. *Pinus* (17.0%) and *Betula* (6.5%) are further excluded as *Picea* (8.5%) and *Abies* 4.8%) colonise the Ore Mountains, followed by the first traces of *Fagus* (0.7%). A thermophilous mixed-oak woodland of *Tilia* (7.1%) and *Ulmus* (6.1%) develops during the Neolithic period, while wetter local conditions are also suggested by the expansion of *Alnus* (to 13.3%) at the margins of the in-filling lake.

Pollen samples taken from the detrital gyttja at 20, 16 and 14 cm date to the later prehistoric agricultural period. The spectrum at 20 cm is Epi-Atlantic (P.A.Z. VII) in date (i.e. Late Neolithic or Eneolithic), in which a continued evolution of sub-alpine woodland is attested by the expansion of *Abies* (15.6%) and *Fagus* (8.0%) which replace *Betula* (1.0%). There is a major decline in *Tilia* (1.3%), while *Quercus* (7.3%) and *Ulmus* (3.0%) also register only half their former relative values, perhaps in part due to the expansion of *Alnus* (21.6%) at the lake margin. Perhaps due human impact, N.A.P. also registers an expansion (to 4.3%), although only a single grain of *Galium* is likely to be of an arable weed. Otherwise, a limited pasture and fallow vegetation is indicated by *Gramineae* (3.0%) and *Artemisia* (1.3%).

The spectrum at 16 cm is later Epi-Atlantic or Eneolithic in date, when the in-filling of local lake beds leads to the expansion of *Alnus* (rising to 26.5%). Human impact increases as N.A.P. rises to 6.7%, this consisting of a pastoral-wasteland mix of *Gramineae*, *Artemisia*, *Asteraceae* and *Calluna vulgaris*. The pre-degradation sample at 14 cm is Sub-Boreal in date, with a spectrum which correlates with Firbas and Losert's local P.A.Z. VII/VIII transition (dated *via* pottery to the Early Bronze Age).[3] Non-tree pollen registers continued localised human impacts (4.0%), although cereals and weeds of cultivation become more prominent (2.4%). *Pinus* also reappears at this time (7.9%) in tandem with *Betula* (3.6%), representing secondary growth (?). With the rise of *Alnus* (to 36.9%), tree pollen of all other types decline.

The site of Komořany illustrates two aspects of differential pollen recruitment into lake sediments. Firstly, a substantial contribution by upland streams stemming from the Ore Mountains is discernible from Middle Holocene times, when the mixed-oak woodland is presumably the dominant aspect of the vegetation. It is likely that (ca.) 40% of the pollen deposited at Komořany comes from these sources, as represented by *Pinus*, *Picea*, *Abies* and (in part) *Fagus*. Secondly, local over-representation by *Alnus* makes-up much of the reminder, (i.e.) flora at stream and lake margins is the primary source of pollen at Komořany, registering between 70 and 80% of T.L.P. by Late Epi-Atlantic times. Although continuous prehistoric

3 Firbas 1949

settlement lay no further than 0.5 km from the monolith site, the relative poverty of N.A.P. is understandable when it also understood that this component will be under-represented by a factor of five (or more). It is likely that a similar riparian pollen over-representation has favoured the recruitment of A.P. into lake sediments at Vracov and Mistřín in South Moravia.[4]

Bylany 1

The pollen site of Bylany 1 (287 m a.m.s.l.) in East Bohemia contains the oldest pollen deposits retrieved by the author. The site Bylany 1 itself also represents the most-intensively excavated Primary Neolithic settlement in Central Europe, with an occupation spanning some 600 (cal.) years of the Linear Pottery Culture (Fig. 24). With the Primary Neolithic abandonment, Bylany 1 sees no further settlement until the Early Middle Ages (a hiatus of ca. 5000 years).

Six trial borings were first placed in the "flood plain" of Bylany creek in order to determine the nature of alluvium here, and encountered a uniform 1.5 m deposit of unconsolidated silt resting on lag gravels, sediment probably too shallow to be of likely Neolithic date. Then a seventh boring was attempted by the Neolithic site, in a swale abutting a tiny, unnamed stream. This encountered <u>4.8 m</u> of unconsolidated sediment and terminated in a basal clay (Fig. 25).

Of these 4.8 metres of unconsolidated sediment from Bore 7, the lower 60 cms (4.8 to 4.2 m) consists of alluvium (well-sorted grey silt with clay traces). The colour of this lower sediment suggests it is deposited under anaerobic conditions. Above this lay a 2.45 m thick (4.2 to 1.75 m) layer of colluvium, consisting of silt, sand, traces of clay and gastropod remains. This latter colluvial deposit is unweathered, suggestive of relatively <u>rapid</u> deposition. Significantly, above this colluvium lay a 25 cm thick layer (1.75 to 1.5 m) of <u>weathered</u> palaeosol, with a brown coloured (relict) A-horizon and an iron oxidised B-horizon (clay-enriched), reflecting low-rates of deposit. After this phase of stabilisation and soil formation, further colluviation by silt, sand and clay is encountered between 1.5 and 0.5 m, capped by an amorphous plough-soil.

The lower 60 cm section of alluvium proved amenable to pollen analysis, which indicates a Latest Glacial or Pre-Boreal to Boreal or Early Atlantic date of deposits after Firbas (calculated as T.L.P., see Fig. 26). The sample at 4.8 m (Younger Dryas or Earliest Holocene?) is dominated (52.0%) by taxa typical of the steppe: *Cyperaceae*, *Gramineae*, *Artemisia* and

4 Cf. Rybníčková and Rybníček (1972), Svobodová (1989), Griczuk (1950) and Bonny (1976, 1978).

Polygonum viviparum. Remnants of the tundra scrub-woodland are also prominent (14.0%): *Populus*, *Betula* (presumably *B. nana*) and *Salix*.[5] *Pinus* also contributes large quantities (34.0%) of pollen at this time, although given the poor pollen productivity of the peri-glacial steppe, this genus might not be present locally. The sample at 4.6 m (embedded with macro-sub-fossils of pine) is probably Pre-Boreal in date.[6] The spectrum at this level is dominated by *Pinus* pollen (81.5%), so that other taxa are "artificially" depressed. The first traces of more mesic taxa of the *Compositae* and *Caryophyllaceae* also attest to moistening of the steppe environment at this time. The sample at 4.4 m is Pre- or Early Boreal in date. With the termination of *Pinus* macro-fossil deposition, pollen values of pine also decline (26.1%). Conversely, the first traces of deciduous woodland taxa appear, led by *Alnus* (1.0%) and *Tilia* (0.5%), while the pine-led depression of non-pine pollen curves is also alleviated, leading to a relative reflux of steppic pollen. The steppe as such (65.2%) consists of larger quantities of composites, as well as *Rumex acetosella.* The sample at 4.2 m is Boreal or Earliest Atlantic in date, in which pine continues to decline. Herbaceous vegetation (63.9%) now consists of a wider range of species, including cheno-ams, grasses, sedges and composites. The emergent mixed-oak woodland rises (20.7%), led by *Alnus*, *Corylus* and *Tilia* (7.7, 7.7 and 3.0% respectively). Traces of *Picea* and *Abies* (1.2% respectively) also appear at this time.

Although the author has failed to recover the desired Neolithic pollen spectra adjacent to Bylany 1, the negative evidence for subsequent alluviation is itself indirectly suggestive of certain conditions of early agriculture. With the establishment of a mixed-oak woodland dominated by *Tilia*, soil conditions stabilise. Apparently, the 30 hectares of agricultural settlement at Bylany 1 has been of an intensity insufficient to produce an entrainment of silts from arable fields and reduced evapo-transpiration necessary for alluviation. Nonetheless, considerable colluviation has taken place at the edge of the old terrace of the Bylanka, as attested by 4.2 m of net accumulation on the now gentle slope abutting Bylany 1. Correlating the date of the last pollen spectrum at the boundary of the Boreal and Atlantic periods at (ca.) 7,000 cal. BC, an average rate of colluviation of about five cm per century is estimated. However, colluviation has not been continuous, as attested by the intervening palaeosol.

The best interpretation of the palaeosol (1.75 to 1.5 m) is that it reflects a stable interval between the Neolithic and Medieval settlement. Given this pulsatory hypothesis, a rate of colluviation corresponding to the 600 calendar year occupation at Bylany 1 would average (ca.)

5 Cf. Huntley and Birks 1983

6 Miss Ogilvie of the Department of Archaeology, University of Durham performed this thin-section identification.

41 cm per century, somewhat higher than the *circa* 33 cm per century deposited into the ox-bow lake at Pleszów (Nowa Huta) in South Poland during the Late Neolithic occupation, and yet somewhat lower than the peak of 50 cm per century deposited at the edge of the hunter-gather settlement at Koster in the Mid-western United States.[7] Early farmers at Bylany 1 thus never perturb root structures to a degree that sheet-wash and silt-entrainment ensued. Not until the wider use of the traction-ard will sufficient root-mat perturbation occur to allow for the initiation of "flood-loam" deposition in the lower order stream basins of Bohemia. Indirectly, the lack of Early Neolithic alluviation at Bylany 1 may reflect then the local practice of hand-tillage, which leaves root structures intact and deters soil erosion.

Konobrže

Konobrže (269 m a.m.s.l.) in the brown-coal district in Northwest Bohemia lies some 15 km north-east of Komořany. Salvage excavations by P. Čech in the path of the Ležaký open-cast mine were visited by the author after 1993-4, when four samples for pollen analysis were taken from archaeological contexts spanning the Early Eneolithic until the Late Bronze Age (Figs. 27). The terrestrial origin of these samples would suggest that the constituent spectra reflect local rather than regional vegetation patterns.

Early Eneolithic probes from Konobrže stem from the primary and secondary fills of an enclosure ditch containing pottery of the Funnel Beaker Culture (Fig. 28). The primary fills consist of silts, where before the removal of up to one metre of top-soil *via* machinery, minimum depths of deposit of 130 to 135 cm might be reconstructed. The inter-digitation of soil profiles within the limited preserved section is also suggestive of rapid deposit, sedimentary conditions also encouraging pollen preservation. Given the exposure of the ditch to saltation, it might also be assumed that much pollen has entered into the ditch with wind-bourne dust particles.[8]

The Early Eneolithic spectra reflect the initial stages of land-clearance at Konobrže, from the time of the first local establishment of agricultural settlement (Fig. 30). The spectrum from the primary fills reflect an arboreal flora, as represented by primary (19.1%), secondary (14.9%) and alluvial (17.0%) woodlands. The hard-woods consist of both a dominant *Tilia* and an ascendant

7 Cf. Godłowska et al. 1987, Butzer 1977

8 Cf. Anderson (1974) for his account of pollen recruitment into Tauber traps following a dust-storm by Draved Wood in 1967.

Fagus, while secondary woodland consists of an even mixture of *Corylus* and *Betula*. Alluvial woodland is prominently represented by *Alnus* (14.9%), shielding the pollen of *Salix* (2.1%) in the lower flood zone. The open landscape consists of a pasture of *Gramineae* (17.0%), *Rumex acetosa* (2.1%), *Asteraceae* (2.1%) and *Compositae lig.* (4.3%). Definitive signs of arable cultivation are lacking, however ruderal wastes of *Plantago media* (6.4%) might reflect an arable regime with longer fallows. With the establishment of local agriculture, more extensive local clearance is indicated by a decline of A.P of all classes. Primary woodland (*Quercus* and *Abies*) comprises only 3.5% of T.L.P., while secondary and alluvial woodlands decline to 2.3% and 9.3% respectively. The open landscape component is transformed, as reflected in an influx by the insect-pollinated *Compositae lig.* (40.7%). This transform occurs in tandem with the development of dry wastes, although this may also reflect local (gravity-component) over-representation, in view of which the local clearance might not extend further than 200 to 300 metres.[9] An expansive fallow land is suggestive of a more-pastoral mixed agriculture, perhaps within a clearing of (ca.) 30 hectares. Given a lack of annual weeds, fallows of up to 10 years might be reflected.[10]

After the Early Eneolithic occupation, site re-visitation is indicated by mortuary finds of the Early Bronze Age Únětice Culture, from which a third sample for pollen analysis derives from a vase of Moucha Phase 2 or Early Únětice Culture (Fig. 27). Notably, this vase comes from a stone cist grave (18) under a burial mound of this culture (i.e., from a relatively anaerobic deposit), although only a small quantity of pollen (302 grains) was recovered from five cm^3 of sediment in the Únětice vase. This sediment most likely derives from (Early Bronze Age) topsoil near or atop the mound, which may contain quantities of still-older pollen resistant to decay. Note then the quantity of *Pinus* (25.2%) encountered, which might be excluded from further interpretive consideration. Otherwise, the <u>local</u> vegetation consists of a pasture (50.7%) surrounded by woodland, which has recolonised the original clearance. Fallow vegetation (*Chenopodium* and *Caryophyllaceae*) increases together with the appearance of the annual *Polygonum aviculare* (0.7%), with primary cultivation indicators of *Humulus* (0.7%) and traces of *Cerealia* (0.3%). Rather extended fallows are indicated after the general proportion of perennial to annual weed vegetation, fallows extending perhaps up to ten years. Incidentally, a long-house (ca.) 20 m long was also discovered at Konobrže, housing perhaps a macro-family.

9 Cf. Lange 1971, Behre and Kučan 1986

10 One hectare of corn is capable of supporting one family of five after Soudský and Pavlů (1972) and Dresslerová (1995b).

Final samples for pollen analysis were taken from an alluvial and colluvial deposit dated by Late Bronze Age (Knovíz) pottery (Figs. 29-30). Because this deposit has formed under the water-table adjacent to the site, archaeological pollen to be described has been preserved through anaerobic conditions. With (secondary?) *Pinus* levels (27.9%) near those of the Early Bronze Age, higher values of alluvial and secondary woodland are registered in this riparian setting, with *Alnus* (6.3%) and *Betula* (5.4%) prevailing.[11] Locally, pasture predominates (30.6%), although culture-steppe (5.4%) and fallow fields (9.9%) are also prominent. Extensive arable fields are comprised of *Cerealia* (0.9%), *Triticum* (1.8%) and *Humulus* (0.9%). Given the poor production and dispersion characteristics of some of these arable taxa, this Knovíz primary cultivation signal of 3.6% should be regarded as significantly high. Moderate pollen representation by annual weeds are also suggestive of shorter fallows, of five or more years on the basis of the proportion of of annual *vs.* perennial weeds.

In summary, the Konobrže evidence reflects on three themes. Firstly, pollen spectra from (terrestrial) archaeological sites are not sensitive to relative deforestation beyond a local (2-300 m radius, cf. Chapter 3) threshold. Only the initial Eneolithic spectrum reflects high levels of aforestation, a forest which also indicates a local *Tilia* rather than *Quercus* dominance. Secondly, agricultural intensity in the Eneolithic and Earliest Bronze Age is low, with fallows of (ca.) 10 years on cleared land on the basis of the proportion of of annual *vs.* perennial weeds. The methodology employed follows that of K.E. Behre in which under non-intensive cultivation, only a minor admixture of annuals might be encountered according to a declining (logarithmic) scale with lower intensity agriculture.[12] Cultivation within the local clearance reaches its maximum then in tandem with erosion and accumulation in the Late Bronze Age. Thirdly, tree pollen might be generally depressed by a local over-representation by insect-pollinated, gravity component taxa.

Limitations for the interpretation of Konobrže also lie in the potential for ditch-fill and archaeological pollen spectra to contain secondary pollen grains which do not reflect true vegetation conditions at the time of sedimentation.[13] Although the experience of the author suggests that the cumulic soils of the area will contain little preserved pollen outside of pine, a

11 Kyncl (1987a, 1987b) notes exceptionally high levels of *Betula* macro-sub-fossil representation at Late Bronze Age sites in the basin of Lužický potok, perhaps indirectly reflecting extensive-land-use and clearance favouring the formation of secondary woodland.

12. Behre 1981

13. Cf. Dimbleby 1985, Faegri et al. 1989

certain over-representation by degraded specimens of this type in some of the site deposits suggest that conclusions drawn from this site should be regarded as tentative. However, aspects of the Konobrže data are supported in some data patterns discernible from the main geo-botanical site of Vranský potok (e.g., in the higher agricultural settlement intensity of the Late Bronze Age period). The author suggests that the pollen data from Vinoř (see below) and Pannonian archaeo-palynological sites (see Chapter 7) will be more reliable after a visibly pristine condition of the pollen. It is likely that the pollen from these latter sites are better preserved due to a more rapid rate of sedimentation at the latter sites (into storage pits and very deep ditches) which has better inhibited oxygen exposure and microbial degradationary vectors.

Vranský potok: site description

Vranský potok (245 m a.m.s.l.) is the principal geo-botanical site investigated, where an alluvial sedimentary sequence spanning parts of the Eneolithic (?) and the entire Bronze, Iron and Early Middle Ages has been recovered (Fig. 31, Figs. 38-45) and analysed for pollen micro-fossils. Three sequential radio-metric assays (Beta 81677, 82510 and 82511) date these deposits (see dates in main diagram in back jacket and in summary pollen diagram in Fig. 37).

In macro-regional terms, this second-order drainage site lies in the northwestern periphery of the Central Bohemian prehistoric settlement cell, only four km from the general watershed of the Vltava River. The agricultural landscape in the local watershed of Vranský potok includes limited (less than 50% of land surface) prime arable tracts which lie near the edge of a sand- and limestone gorge into which the creek channel flows. The coring itself was achieved by hand with a simple Hillier device in the alluvial accretion zone of the north bank of Vranský potok below a small water fall ("Nad Splávem"), at a meander bend where incline and water velocity decline. Due to its complex micro-regional geology, soils in the environs of Vranský potok are based in both basic and acidic geologic substrates, giving rise to a requisite variety of vegetation communities. The rocky places above the edge of the gorge also support a flora adapted to thin and poorly developed soils, places colonised today by scotch pine or *Pinus sylvestris*.

Unconsolidated alluvial sediments at the bore site are deposited up to 4.50 m in depth, and lay upon a weathered layer of pure basal clay (perhaps a diagenic Bt-horizon, cf. Fig. 31). This unconsolidated sediment is comprising three main zones, capped by a 77 cm modern disturbance layer. A lower zone from 450 to 405 cm consists principally of partially oxidised clay, with smaller quantities of reduced silt (or flood loam). The middle zone between 405 and 146 cm consists of alternate layers of reduced silt (indicative of aquatic or high-water tables) and telmatic detrital peat with silt (indicative of low water tables). The upper zone from 146 to 77 cm consists of a reduced mix of silt and clay which is poor in organics. In this upper zone, the stream has lost some of its competence relative to its increasing sedimentary load, leading to an increased fall-out and deposition of clay. This sub-competent upper zone is cut at 127 to 125 cm by a layer of pure sand, representing a high-energy erosion and accumulation event, possibly following a flood involving a Hortonian entrainment of sand particles from surrounding arable fields (cf. Figs. 32-36).

Vranský potok: radio-carbon dating and rates of accumulation

Three radio-carbon assays were obtained from organic-rich layers between 345 and 200 cm, assays of Late Bronze and Terminal La Tène or Early Roman Iron Age date (cf. Chapter 5, Horizons II and III). Two samples (Beta 82510 and 81677) are derived from sedge peats from which root material was carefully screened, while one (Beta 82511) is assayed from a young wood macro-sub-fossil, this probably deriving from willow. The carbon assayed thus relates to plant growth either contemporaneous with or immediately prior to the sedimentation of alluvial (mineragenic) particles and associated pollen assemblages.

Note that no stratigraphic unconformities suggestive of higher energy deposition (with a higher potential for a reworking of alluvial sediment) are to be found in the sediment cores outside of a narrow band of pure sand (125-7 cm, Fig. 31). According to the more recent alluvial palynological experience of the author, highly variable rates of accumulation are most typical of coarser gained alluvial sediments where a potential for reworking is greater, or from larger rivers where a considerable lateral variability in alluvial accretion rates will be experienced. Neither scenario describes the situation at the main geo-botanical site. More incremental variation in sedimentation rates might still follow from the degree of telmatic influence (which promotes the development of sedge peats).[14]

Importantly, the three dates are consecutive with respect to depth (cf. Fig. 37). These dates are presented below and (parenthetically) calibrated after one-sigma time-spans after the 20-year

14. Cf. Troels-Smith 1955

atmospheric curve:[15] The middle part of each calibrated range is then employed to estimate rates of sedimentation.

Beta 82510 (345 to 341 cm): 3070 uncal. ±60 BP (1406 to 1259 cal. BC)
Beta 81677 (312 to 308 cm): 2790 uncal. ±50 BP (994 to 892 cal. BC)
Beta 82511 (202 to 200 cm): 2020 uncal. ±50 BP (50 cal. BC to AD 60)

An important independent check on the reliability of these dates comes from a distinctive dual rise in the curves for *Secale cerealia* and *Centaurea cyanus* in Pollen Assemblage Zone 18, beginning at 146 cm (see main diagram in back jacket). Extrapolating from Beta 82511 to the modern surface and assuming a constant rate of sedimentation, one would calculate that this sediment was deposited at about AD 550, while dates for the emergence of a *Secale cerealia*-based agriculture (with *Centaurea cyanus* as an associated arable weed) may be placed at *circa* AD 550-600, during the Early Slavonic period.[16] This relative agreement in extrapolated *vs.* relative date estimates also suggests that sedimentation rates within this low-energy environment are relatively continuous, an assumption supported by the relative comparability of mean sedimentation rates as indicated by the dates and their depth relative to the modern surface as discussed below.

From these assays, a rate of (lower) middle zone silt deposition (405-345 cm) can be extrapolated, whereby one cm equals approximately 12.5 calendar years, based on the same interpolated rate between assays at 345-341 and 312-308 cm of the (middle) middle zone. A somewhat faster rate of accumulation is interpolated between assays at 312-308 and 202-200 cm in the (upper) middle zone, whereby one cm equals approximately 8.3 calendar years. A slightly slower rate of accumulation is interpolated after the final assay (200 cm to surface) in the (upper) middle and upper zones, whereby one cm equals approximately 9.8 calendar years. Much more problematic are estimates of rates of deposit in the lower main sedimentary zone (below 404 cm), beyond the range of the radiocarbon dating program.

This lower main sedimentary zone (404-450 cm) must have been deposited at a much slower rate, given the great predominance of (very low-energy) clay deposition within this unit (Fig. 31). This rate might be slower by a factor of three or more relative to the middle and upper zones, an assumption affirmed by the weathered quality of the sediments from the lower zone, although

15. Stuiver and Pearson 1993, Pearson and Stuiver 1993, 1986a, 1986b

16 cf. Wasylikowa et al. 1991, Jankovská 1990

this must remain a rough estimate at present.

Conversely, the middle main sedimentary zone (404-146 cm) is deposited at higher rates on the same principle, although silt deposition slows when telmatic influence increases. It should be noted that the character of sediments between 404 and 345 cm is very similar to that of the well-dated sediments between 345 and 200 cm, thus estimates as to rates of sedimentation may be less problematic herein. The upper main sedimentary zone (146-77 cm) reflects conditions of deposition whereby changes in water-table relative to the alluvial accretion surface are obscured by a generally high sediment load which is poorly-sorted. Unlike the lower zone, the upper clays are unweathered and reduced, indicating a more rapid and sub-aqueous accumulation relative to the lower zone. These upper zone conditions are reflective of enhanced erosion and sub-competent accumulation under very intensive agriculture and a high water table. As noted above, there are independent (relative botanical) lines of evidence supporting an assumption of constant rates of deposition between the ultimate assay and the present alluvial accretion surface.

Vranský potok: geo-botanical methodology

The pollen sampling at Vranský potok was performed using a standard interval of four cm for samples from 424-110 cmbs (less regular sampling was employed for the Medieval period). After the radio-metric dating above, this sampling interval would signify a chronometric one of only 30-50 years between individual consecutive pollen spectra within the middle and upper zones. It is presumed that intervals between spectra are longer in the case of the lower zone, somewhere in the order of 100-200 years. Microscopic analyses of these pollen assemblages were performed on a Zeiss light microscope at x400 magnification for scanning purposes. Only rarely is pollen preservation problematical, so that counts of between 200 and 500 grains were readily achieved. For more detailed taxonomic work, immersion oil was used in conjunction with x1000 magnification. This level of magnification was used for the identification of all cereal grains (after the method of K. Wasylikowa)[17] with the exception of *Secale cerealia*.

It became apparent during the process of pollen counting that distinctive changes in the pollen spectra were occurring which could not be explained in ecologic terms, namely a strong positive co-variation between saccate pollen grains (*Pinus*, *Picea* and *Abies*), semi-aquatics (*Typha latifolia* and *Typha angustafolia*) and riverbank flora (*Cyperaceae*). Given the great edaphic

17 K. Wasylikowa pers. comm. 1991

differences between the terrestrial to semi-aquatic species represented by these pollen types, such co-variation might be best explained by means of an extension of the "Neves-effect" to alluvial pollen situations as reviewed in Chapter 3 (cf. Figs. 32-36).

Pollen groups excluded from the Adjusted Land Pollen sum

For purposes of review here, by the Neves-effect it is meant that saccate grains are deposited onto the alluvial accretion surface not in suspension, but rather as a floating component, carried on the water's surface by their buoyant air-sacks. Because of this characteristic, saccate grains are more-likely to be deposited under a low water table, when these grains are skimmed onto the alluvial accretion surface. Due to the particular flood-plain geometry at Vranský potok, these same low-water phases also give rise to local communities of semi-aquatic reed-mace and riverbank sedges, increasing their relative (local) representation (cf. Figs. 35-36). Also during these same low-water phases, other land pollen in suspension will be represented to a lesser extent, as their deposition is dependent on the volume of water flow over the alluvial accretion surface. During high water phases, these processes are reversed, leading to higher land pollen (*sans* saccates) concentration (cf. Figs. 34).

The interpretation of these phenomena are well-supported in the curve of added *Lycopodium* to land pollen, for as this proportion increases, lower rates of pollen deposition per unit volume of sediment can be inferred (cf. Table 6.2 below). These relationships are illustrated in the first summary pollen diagram of Vranský potok, calculated after unadjusted T.L.P. (i.e. including saccates, but excluding telmatics, see Fig. 37 for a summary diagram after total land pollen). Because of this differential recruitment mechanism, saccate pollen grains are excluded from the pollen sum for further interpretative purposes, as are locally over-represented semi-aquatic and riverbank communities. After these adjustments to the T.L.P. sum ("adjusted land pollen" or "A.L.P."), co-variation between the pollen of saccates and telmatics and *Lycopodium* (spores) is statistically enhanced. Three pollen components are excluded from the A.L.P. sum at Vranský potok as described below in relation to the geo-botanical of the site:

1. Saccates: in respect to saccate grains, general proportional changes are discernible between the early dominance of *Picea* over *Abies*, which is terminated after the Loebben (cold) oscillation (cf. Zone 4?). It may be presumed that the latter event, in destroying the seed banks of *Picea*

(sensitive to early spring frosts), leads to its replacement by *Abies* within the regional context. Unsurprisingly, *Pinus* constitutes the primary saccate type, although *Picea* also enjoys a terminal dominance (Zone 22), reflecting the establishment of spruce plantations during the Middle Ages.

2. Semi-aquatics: lesser and greater reed-mace constitute the primary taxa of this floral community until the Early Slavonic period, when high-water (aquatic) *Nymphaea* and (aquatic to semi-aquatic) *Potomegeton* rise to dominance for the first time.

3. Riverbank meadows: prior to the Iron Age, *Cyperaceae* constitutes the primary (local) telmatic species, amongst which it always remains an important member. Species also typical of wet meadows have been semi-arbitrarily included in this vegetation community, namely *Myricaria germanica*, *Filipendula*, *Lythrum* and *Scabiosa* (Devil's bit scabiose).

Pollen groups included in the Adjusted Land Pollen sum

Further relationships become apparent between the above pollen-recruitment triad and land pollen in suspension (Groups 4-11 below), whereby low-water phases are associated with aforestation and low cultivation levels. Conversely, extensive cultivation and deforestation are associated with high (relative) water levels, although this relationship is obscured in the upper sedimentary zone due to sub-competent alluviation. Perception of this dynamic relationship is complicated in some cases by short-term cycles of cultivation, when secondary syn-anthropic communities (culture-steppe and fallow) peak out-of-phase (lag) with primary cultivation.

It is likely that this relationship reflects the lower interception of rainfall as deforestation proceeds. During phases of aforestation, more rainfall is intercepted by root matter or transferred to the atmosphere *via* evapo-transpiration (cf. Fig. 32, Figs. 33-6 and Table 6.1 below).[18] Components of the A.L.P. sum include:

4. Alluvial woodland: consisting of (lower flood zone) *Salix* and (upper flood zone) *Alnus*, the latter is prominent in (Eneolithic?) Zone 2 only. *Salix* inhabits places less likely to be exploited, and is sensitive to different thresholds of hydrological change. Peaks of *Salix* pollen are often associated with low-water phases, when it becomes a major element of the local vegetation during the Middle La Tène and Late Roman Iron Age woodland regeneration periods. *Salix* also peaks during periods of most-intensive cultivation, presumably when water-tables are sufficiently high

18 Cf. Butzer 1982, Binns 1979

to enable its expansion towards the terrace edge, for example during the more-intensive cultivation phases of the Štítary Urnfield and Early Slavonic periods.

5. Woodland: climax vegetation consists today of *Quercus* and *Fagus*, although in prehistory, *Ulmus* and *Tilia* are somewhat more important. After the Early Iron Age, *Ulmus* disappears, while *Carpinus* first appears in the Middle Bronze Age. Isolated appearances are also made by *Taxus*, *Juglans* and *Acer*. Primary woodland generally rises with recessions of primary cultivation. A sustained ability for forest regeneration is exhibited throughout the sequence.

6. Secondary woodland: in addition to *Betula* and *Corylus*, this community includes a wide range of shrubs, as well as shade-tolerant herbs (e.g. *Oxallis acetossela*, *Stachys sylvestris* and *Melampyrum*). Secondary woodland is particularly favoured during "cyclical cultivation phases" to be described below. Both *Corylus* and *Betula* are important elements in the earlier vegetation pattern, although *Corylus* never recovers from a Late Bronze Age clearance. *Betula* furthermore enjoys a period of greater prominence during the Middle and Late La Tène Iron Age. Shade-tolerant *Melampyrum* is closely allied with recessionary phases, particularly that of the Tumulus Culture recession (Zone 4), when it attains its absolute maximum.

7. Pasture: constituting the dominant non-arboreal floral community at Vranský potok, pasture is dominated by *Gramineae* pollen. The division of *Gramineae* into size classes was initially made in fear that some (smaller than 27 μ) *Gramineae* pollen might represent local (gravity component) *Phragmites*. Further finds of acido-phytic semi-aquatics (esp. *Ludwiga*) allayed this fear (*Phragmites* likes basic conditions). Other pastoral taxa include a variety of perennials generally correlated with cultivation phases, while the *Umbelliferae* and *Rosaceae* also represent species of forest verges. *Plantago lanceolata* (an inhabitant of grazed pasture) enjoys multiple peaks, first during the Early Knovíz extensive cultivation phase, and then during the Early Iron Age. Asters rise to special prominence in pasture in the Hallstatt and La Tène Iron Ages, a transform which might have been brought-about by the promotion of hay meadows with the Late Hallstatt development of the iron sickle (see below).

8. Culture-steppe: taxa of this floral community thrive on dry or well-drained soils. As a group, it is distinct from wet pasture in that both warm climate and extensive cultivation favour its formation through the desiccation of soils. Culture-steppe formation occurs locally during the Late Bronze Age, the Late Hallstatt and the Early Roman Iron Age. The indicative land-use value of the culture-steppe lies between and partially over-laps those of pasture and fallow. For example, the forb *Artemisia* is also a "ruderal" nitrophile.

9. Fallow: primarily perennial ruderal species thriving on disturbed or nitrogen-rich soils make up most members of this floral community. *Caryophyllaceae* constitute a major element of this ruderal class, with sporadic representation throughout prehistory. *Plantago major* and *Plantago media*, both perennial taxa of partially disturbed soils, are most common in the Late Bronze and Early Iron Ages. *Chenopodium* becomes particularly important during the Middle to Late La Tène, when it associated with peaks of *Polygonum aviculare*. The nitrophile *Urtica* subsequently makes an isolated appearance during the Roman Iron Age. These fallow plants probably inhabit the same fields as arable weeds (in phase-lag).

10. Weeds of cultivation: these (mainly) annual plants follow closely cycles of cultivation. An archaeo-phyte of this class is the annual *Polygonum aviculare*, a taxon which tolerates trampling and compaction of its soil seed-bed. Because of the latter characteristic, it might be presumed that *P. aviculare* will also be favoured by more pastoral forms of agriculture. Characterising moderately-intensive regimes is the biennial *Polygonum persecaria*, which first appears during the Late Bronze Age. Perennial species such as the *Agropyron*-type are also assigned to this class due to an ability to tolerate root system disturbance. Other members of this community include weeds favoured in winter fields, for example *Polygonum convolvulus*, *Agrostemma githago* and *Centaurea cyanus*. Amongst these disturbance taxa, *P. convolvulus* first appears in the Late Bronze Age, becoming common during the Iron Age. *Agrostemma githago* (later) first appears at the very end of the Bronze Age, and becomes an important element in rye fields in the later First Millennium AD (with *C. cyanus*).

11. Cultigens: earliest (Zone 1) primary cultivation indicators include *Hordeum* and undifferentiated *Cerealia*. The very rarely encountered *Linum usitatissimum* (an oil and textile crop whose pollen is quite large, and consequently, poorly distributed) later appears in the Early Bronze Age. *Humulus* (an important secondary crop for cordage and beer brewing) appears first during the Late Bronze Age. Differentiated *Triticum* also also appears first during the Late (Knovíz) Bronze Age, although it is likely that most of the undifferentiated *Cerealia* also belong to this genus. A Terminal (Štítary) Bronze Age addition to this medley is *Cannabaceae*, a fibre-crop which appears again during the Early Slavonic period. A final primary cultigen to appear is *Secale cerealia*, with sporadic finds dating from the Early Iron Age and Late La Tène periods. Only with the Early Roman Iron Age does *S. cerealia* achieve a rational representation. By the later First Millennium AD, *S. cerealia* has become the dominant food crop.

Spores

Endemic fern spores are excluded from the A.L.P. sum. Ferns usually occur in woodlands as part of a bracken vegetation. As a background noise, spores should generally co-vary with added *Lycopodium* in an inverse relationship to pollen concentration. Observed mutual relationships of differential pollen recruitment and sedimentation are now summarised.

Table 6.1. Sedimentation regimes and water-borne pollen recruitment mechanics inferred to be affected by agricultural settlement as reflected in the geo-botanical sequence at Vranský potok

Sedimentological composition of core matrix associated with given pollen zone (and main sedimentary zone)	*Saccates, riverbank and semi-aquatic pollen response in given pollen zone*	*Pollen concentration and cultivation (and general non-arboreal) pollen response in given pollen zone*	*Interpretation of different pollen recruitment mechanics in terms of hydrology, with anthropogenic forcing factors inferred in given pollen zone and associated sedimentary matrix*
1. Weathered clay with traces of silt. (lower main sedimentary zone)	low initial response	Positive tendency	Initial cultivation phase with slow accumulation of sediment in valley prior to release of significant quantities of silts *via* sheet-wash. First major cultivation leads to a modest increase in water-borne pollen recruitment, some oxidation of sediments is apparent. Conditions for semi-aquatic flora are sub-optimal.

Table 6.1. continued

Sedimentological composition of core matrix associated with given pollen zone (and main sedimentary zone)	*Saccates, riverbank and semi-aquatic pollen response in given pollen zone*	*Pollen concentration and cultivation (and general non-arboreal) pollen response in given pollen zone*	*Interpretation of different pollen recruitment mechanics in terms of hydrology, with anthropogenic forcing factors inferred in given pollen zone and associated sedimentary matrix*
2. Weathered clay with traces of silt and telmatic peat accumulation (lower main sedimentary zone)	Positive tendency (*Alnus*), with low response levels of herbaceous semi-aquatic elements	Negative tendency	Relaxation of initial cultivation phase (s), with lower water tables and *Alnus* recolonisation. Some oxidation of sediments is apparent. Conditions for semi-aquatic flora are sub-optimal.
3. Silt with lesser telmatic peat accumulation (middle main sedimentary zone)	Negative tendency	Positive tendency	Fluvial system at higher water levels due to farming impacts on soils. Very high levels exclude local semi-aquatics and reduce "floating" (saccate) pollen recruitment into sediment which is permanently inundated.
4. Silt with greater telmatic peat accumulation (middle main sedimentary zone)	Positive tendency	Negative tendency	Fluvial system at lower water levels due to lesser farming impacts on soil structure. Lower levels enable the local establishment of semi-aquatics. Periodically lower water table leads to an increased recruitment ("skimming") of saccate pollen.

Table 6.1. continued

Sedimentological composition of core matrix associated with given pollen zone (and main sedimentary zone)	*Saccates, riverbank and semi-aquatic pollen response in given pollen zone*	*Pollen concentration and cultivation (and general non-arboreal) pollen response in given pollen zone*	*Interpretation of different pollen recruitment mechanics in terms of hydrology, with anthropogenic forcing factors inferred in given pollen zone and associated sedimentary matrix*
5. Unweathered silt and (upper main sedimentary zone)	Positive tendency	Positive tendency	Very intense farming results in fluvial system losing its competence as sediment load increases beyond a critical threshold. High sediment load leads to vertical accretion of sediment in excess of level of increased water-flow. Pseudo-low (relative) water level leads to an increased recruitment ("skimming") of saccate pollen. Same factors enable the local establishment of semi-aquatics. High (absolute) water flow enhances pollen concentration.
6. Medium-coarse sand (upper main sedimentary zone)	No pollen	No pollen	High-energy erosion with the deposition of coarser sediments missing a fine fraction (pollen).

Alluvial pollen taphonomy at Vranský potok and a statistical test of the Neves-effect

Inferences made respecting alluvial pollen taphonomy in low-energy accretional deposits have important ramifications for the means of inferring ancient landscape character. Palaeohydrological influences on local vegetation and the relative recruitment of saccate pollen are excluded prior to micro-regional vegetation reconstruction. The statistical transformation imposed on land pollen percentages which followsis thus recognised in the adjusted (A.L.P.) sum. Without this adjustment, variations in the amplitude of A.P./N.A.P. curves are increased (contrary to primary bias as sample size also increases), while the relative level of later prehistoric cultivation is increased relative to that of the Medieval spectra. Thus the A.L.P. adjustment, which serves to reduce the inferred scale of pre-AD 550 agriculture, accords with sedimentology in two zonal contrasts. First, the upper (post-AD 550) zone exhibits evidence for high energy erosion and accumulation which the middle zone lacks. Second, the upper zone experiences alluviation under conditions of reduced fluvial competence, indicating that sediment supply exceeds the ability of the stream to carry its suspended load, a by-product of intensive agricultural practice.

Independent affirmation of differential pollen recruitment processes can be gained in comparing zonal changes in pollen concentration. Land pollen concentration is higher by multiple orders of magnitude in the middle (high water table, particularly Zones 5 and 8-11, see below) *vs.* the lower (low water table) and upper zones (sub-competent alluviation), affirming the notion that pollen concentration is linked to volumetric changes in water flow over the accretion surface. A hydrological and taphonomical dependence of co-variation between *Lycopodium* and floating saccate taxa has been proposed in Table 6.1, and is now statistically supported. Co-variation of individual saccate taxa (with each other) is also supported. Only co-variation significant to a 95% (1/1 and 2/5) confidence interval is employed (Table 6.2 below), after the A.L.P. sum. Importantly, *Lycopodium* lies outside closed (100%) statistical boundaries.

Table 6.2. Co-variation to 95% (1/1 and 2/5) confidence between saccates and A.L.P.C.

Pinus-Picea (no.=11), 100% positive co-variation.	*Pinus-Abies* (no.=36), 100% positive co-variation.
Picea-Abies (no.=13), 77% positive co-variation.	saccates (combined)-*Lycopodium* (i.e. inverse A.L.P.C., no.=32) 84% positive co-variation.

Note that in assessing *Pinus-Picea-Abies* co-variation, relative percentage changes of all taxa must meet the 95% confidence interval standard. Perfect co-variation between pine and spruce or fir cannot reflect actual natural variation, as the edaphic qualities of pine are quite different from spruce and fir. Lower co-variation between *Picea* and *Abies* may reflect the mutually antagonistic edaphic relationship between these taxa, as these often compete for the same habitat. In actual phyto-taxonomical contexts, one would expect significant negative co-variation (increase in one taxon coincident with a decrease in the other) between the latter.

Exceptional negative co-variation may be explained in terms of strong natural and cultural selective pressures. The early (Pollen Assemblage Zone 4, see main diagram in back jacket) negative co-variation episode of *Abies-Picea* at Vranský potok is probably concurrent with the Loebben oscillation, and thus might reflect either the exposure of *Picea* seed beds to early spring frosts, or a promotion of *Abies* in the regional Středo-Hoří due to lower summer temperatures. A terminal episode is contemporary to the influence of Medieval farmers, who are recorded to have established spruce plantations in preference to fir in upland regions of Bohemia.[19] Lower co-variation between proportions of (combined) saccate pollen and low pollen concentration may reflect the fact that *Lycopodium* quanta are subject to phenomena not constrained by the closed 100% statistical universe, reducing its potential co-variation with any quanta within that universe.

The effects of differential recruitment of saccate pollen into lower order alluvial accretion deposits in fluvial systems can be observed to result in reduced down-the-line recruitment of saccate pollen into alluvium of higher order drainages. Thus at Vinořský potok (an eighth order drainage, see below), saccate pollen response is less than 50% of that at Vranský potok (a second order drainage). Also, in the floodplain of the Nitra River, saccate values at Mýtna Nová Ves (see Chapter 7) are consistently less than 10% of the modal range at Vranský potok.

Sources of sediment at alluvial sites also effects relative A.P./N.A.P. ratios. Because alluvium derives from sheet-wash largely entrained by erosion of arable fields and pasture, it is likely that herbaceous pollen will be favoured over tree pollen, given the contextual origin of sediment. Thus, a maximal woodland pollen response of 40-50% at low order alluvial sites (e.g., Zone 4 at Vranský potok) might be comparable to an aforestation level which produces 90-95% A.P. at lake sites (e.g., in Middle Bronze Age spectra at Gopło in West Poland).[20]

In support of the inferred differential pollen recruitment mechanics, it should be finally noted that a Principle Components Analysis run of E. Grimm's TILIA program on A.L.P. data indicate that the largest loadings on the first component of variation belong to *Pinus*, *Picea*, *Abies*, and semi-aquatic pollen taxa which also form the primary basis of pollen zonation at Vranský potok.

19 Jankovská 1971

20 Jankowska 1980

Vranský potok: geo-botanical phases defined in terms of human impact on the environment

The unconventional zonation of the Vranský potok pollen diagram (see main diagram in back jacket) will follow primarily from pollen groups which comprise the main component(s) of variation. These are namely the saccates and semi-aquatic types which vary very significantly according taphonomic factors, factors probably dependent on palaeohydrological change as inferred above. Changes in the main land pollen types are less dramatic, and thus account for a lower level of the statistical variation in the diagram, although these are more significant for purposes of inferring ancient land-use. Fortunately, enhancements of hydrological levels would also appear to be related to land-use intensity as described below. Because of the sensitive nature then of hydrological change relative to the alluvial accretion surface at Vranský potok, the diagram will appear to be over-zoned relative to the degree of change actually expressed in the extra-local land pollen assemblages which directly reflect human land-use. To an extent, zonation is also adjudicated to aid comparisons to archaeological periods (a specific analytic intent of this work). In one case (Zone 9), few major palynological differences between prior and later zones can be observed, although as settlement archaeology will later indicate (in Chapters 10-11), this phase is one a major change in settlement dynamics. In this latter case, the differentiation of the zone serves the purpose of drawing attention to a phase which might be considered a focus of comparison between the geo-botanical and archaeological records.

Importantly, the dating of early pollen zones (1-4) remains open to doubt, although reasonable estimates as to date might be made as discussed above. These zones are thus signified with a parenthetical query (?) as to the age of deposit. These Zones 1-4 are also ascribed to very general archaeological periods such as the pre-Bronze Age (Zones 1-2) or earlier (i.e., Early and Middle) Bronze Age (Zones 3-4). A query should also be posited as to the exact association of the Hallstatt C period with Zone 9, although this is not critical to interpretation, as this is the least distinguishable zone in the entire sequence.

Palynological and sedimentological descriptions of individual pollen zones are then followed by a an interpretation of the primary geo-botanical data set. In the latter section, local archaeological findings as well as the reflection of prehistoric settlement after anthropogenic pollen indicators are considered. It should be repeated that a "splitting" rather than "lumping" methodology to zonation, focusing on hydrologic and anthropogenic indicators, has been employed. A zonation based on major tree species would produce fewer "zones" as such.

Zone 1: (424 to 412 cm): in sedimentary terms, clay layers containing the first traces of silt also produce the first well-preserved pollen at a depth of 424 cm. Pollen zonation commences then above this depth level. Significantly, the saccate pollen group (esp. *Pinus* and *Picea*) herein attains a periodic low at 416 cm, synchronous with high values of *Hordeum* and *Cerealia* (3.3%). Other herbaceous taxa associated with the latter rise include *Polygonum aviculare*, *Chenopodium* and *Artemisia*. Pastoral plants occurring with significant pollen representation also include grasses and composites. A rise in secondary woodland pollen representation is also notable at this time, as well as a decline in the mixed-oak woodland component of *Quercus*, *Ulmus* and *Fagus* (which falls to 3.3%). By 412 cm, these primary woodland elements rise again to 10.9%. Secondary woodland elements express initially (at 424 cm) lower values (e.g., *Corylus* at 5.6% and *Betula* at 0.0%) which rise at the terminus of this zone (at 412 cm, to 14.1% and 12.5% respectively).

Zone 2: (408 to 404 cm): in sedimentary terms, clays and silts increase in humate content at this time. High pollen responses of *Cyperaceae* (to ca. 140% of A.L.P.) and particularly of *Alnus* (to 40% of A.L.P.) are notable. *Salix* is also prominently represented. Of annual herbs, only an isolated *Scleranthus* pollen grain is present. Excepting sedge, non-tree pollen response levels expressed are low.

Zone 3: (400 to 384 cm): in sedimentary terms, silt deposition increases by a factor of three relative to low-energy clay deposition, from which more rapid sedimentation regime (cf. Zones 1-2) can be presumed. These geologic developments are accompanied in pollen taphonomic terms by an increased A.L.P.C., as well as a declining saccate and an variant semi-aquatic and riverbank pollen representation. *Cyperaceae* is the most important of the telmatics, and achieves a high representation in places (maximally, 123.2% at the terminus of the zone), although *Typha angustafolia* is also present, and also reaches a zonal high at 384 cm (7.1%). Herbaceous pollen representation reaches a peak at 392 cm, when high relative values of *Polygonum aviculare* (1.1%), *Chenopodium* (2.2%) and *Artemisia* (2.2%) are also apparent. Other weeds appearing at this time include *Galium*, while a notable if singular find is that of *Linum usitatissimum*, a very rare type (it appears only in this level at the site, of approximately 17,000 pollen grains counted at Vranský potok). Otherwise, the initial appearances of the herbs *Centaurea nigra* and *C. scabiosa* in this level are also notable. At the terminus of this pollen zone, the composite mixed-oak woodland group increases from 9.4% to 33.4 %. *Alnus* begins a decline in this zone (from 24.3% to 5.4%) from which it never subsequently recovers. Only modest values of *Quercus* are expressed in this zone, its pollen response levels varying between 7.3% and 16.3%. *Fagus* varies similarly, between 7.3% and 12.9% of A.L.P. Subsequently, *Quercus* and *Fagus* will together comprise the primary part of the primary woodland component.

Zone 4: (380 to 375 cm): in sedimentological terms, there is no apparent change compared to the earlier zone. In palynological terms, variability in aquatic to semi-aquatic pollen response levels is noticeable, first with an acute rise of *Nymphaea* (to 3.1%) and then of *Typha angustafolia* (to 7.3%) with *Cyperaceae* (to 129.3% of A.L.P.). Herbaceous pollen levels are depressed in general throughout this zone. For example, the composite pastoral group (pasture) declines to 19.5% by the end of this period (an absolute minimum), while all definitively annual plants disappear entirely. Isolated finds of *Artemisia* and *Galium* are notable herbaceous finds, however. More importantly, this zone sees an absolute maximum in the shade-tolerant herb *Melampyrum* (9.8%), while the arboreal *Quercus* also rises to 31.7% (also its absolute maximum at the site). Secondary elements such as *Corylus* and *Betula* then recede as the primary woodland elements increase in their relative palynological expression. *Abies* replaces *Picea* (here-after) as the second most important aspect of the saccate group (after *Pinus*, which is almost always the most important saccate taxon).

Zone 5: (372 to 356 cm): in sedimentary terms, a definitive change transpires in this zone, with a change of regime to an exclusive deposit of reduced silts. In palynological terms, saccate pollen declines precipitously to less than one-fifth of its former levels (275.6 to 50.7% of A.L.P. between 375 and 372 cm) while semi-aquatic pollen values fall to negligible (*circa* 1%) values by the end of this phase. In tandem, *Cyperaceae* also falls to its lowest level to date (to 21.8% of T.L.P. in the middle of the zone). Herbaceous species are more emphatically represented in a wide array of tax as follows. An increase in *Gramineae* pollen is four-fold (12.2% to 49.3%), while an increased herbaceous species richness is represented by taxa such as *Mentha*, *Potentilla*, *Rosa*, *Trifolium* (1.4%), *Umbelliferae*, *Ranunculaceae* (2.9%), *Plantago lanceolata* (2.1%, reaching 6.2% by 360 cm) and *Asteraceae*. New herbaceous taxa rising prominence include *Calluna vulgaris* and *Artemisia* (the latter to 8.1% by 356 cm). There is also an isolated occurrence of *Centaurea scabiosa*. Importantly, *Chenopodium* increases at this time, to 8.0% by 360 cm. An annual weed component consists of *Polygonum aviculare*, *Scleranthus* and *Agropyron*. *Humulus*, *Hordeum* and *Triticum* reach 2.0% (in tandem) by 356 cm, when an isolated occurrence of *Ephedra* is notable. Simultaneously, *Quercus* falls from 31.7 to 2.1%, while *Fagus* declines from 7.3% to 4.3% during the same period. Secondary woodland pollen response levels are also low, with *Corylus* values varying between 0.0% and 2.9%, and *Betula* values varying between 3.4% and 6.1% of T.L.P.

Zone 6: (352 to 336 cm): in sedimentary terms, up to 50% of sediment is represented by telmatic humus accumulations in this zone. In palynological terms, variations in saccate pollen occur throughout this zone (*Pinus* from 26.3% to 133.3%, *Picea* from 1.7% to 21.2%, *Abies* from 14.4% to 67.7%). Riverbank *Cyperaceae* also varies widely between 23.7% and 169.9%. Accompanying this suite of phenomena is a rise in woodland pollen, as reflected in the curves of *Ulmus* (which rises to a site absolute maximum of 1.9%), *Quercus* (7.0% to 21.2%) and *Fagus* (1.9% to 8.6%). Secondary woodland elements are also important at this time, as reflected primarily in the *Betula* curve (which varies from 7.0% to 21.4%). Alternate low-level fluctuations in herbaceous pollen are observable, with a minor peak of *Humulus* (1.9%) and *Cerealia* (1.9%) exhibited at 336 cm. Unique (site) appearances at the beginning of this phase include the isolates of *Cruciferae arabis* and *Hippophae*.

Zone 7: (332 to 324 cm): this zone is accompanied after 327 cm by a significant change in stratigraphy, which is indicative of more telmatic sedimentary conditions. Somewhat low saccate and riverbank pollen occur throughout the zone. *Pinus* varies between 40.8% and 98.2%, while *Cyperaceae* varies between 24.1% and 73.2%. At 324 cm, a representation of the annual *Polygonum aviculare* (3.6%), the biennial *Polygonum persecaria* (3.6%) and the annual *Scleranthus* (3.6%) occurs. There is a lack of determinate arable indicators at this time, however. Notably, the secondary woodland pollen group declines after an initial peak (declining from 20.4% to 11.3%), while the primary woodland response increases by 250% compared to 336 cm levels over this period of three to four generations. In particular, *Quercus* rises from 8.0% (at 332 cm) to a maximum of 22.5%, while *Fagus* rises from 8.0% (at 332 cm) to 16.4% at the terminus of this zone.

Zone 8: (320 to 308 cm): in sedimentary terms, this zone sees a return to a dominance of reduced silt deposition. Saccate values are low (*Pinus* declines to 27.1%), while *Cyperaceae* values are very low (declining to 7.8%). *Hordeum* (0.8%), *Humulus* (to 1.0%) and *Cannabaceae* (to 1.9%) occur during this phase, reaching a combined level of 2.3% at 308 cm. Weeds represented include the biennial *Polygonum persecaria* (to 1.0%), and the annual *Polygonum aviculare* (to 3.9%). Other herbs appearing for the first time include *Agrostemma githago* (to 0.8%) and *Centaurea cyanus* (to 0.8%). Combined *Artemisia* and *Calluna vulgaris* attains an absolute site maximum at this time, when the combined pasture group attains its highest representation to-date (64.3%). Conversely, combines alluvial and mixed-oak woodland groups decline (the former to 3.1% with *Alnus* at 2.3% and *Salix* at 0.8%, the latter to 11.6%, with *Quercus* at 6.2% and *Fagus* at 2.3%).

Zone 9: (304 cm): in sedimentological terms, no change is registered in this zone. In palynological terms, saccate group pollen (47.6%) and *Cyperaceae* (13.5%) remain suppressed as A.L.P.C. increases. The primary woodland pollen group doubles in its relative response(from 11.6% to 21.4%, with *Quercus* and *Fagus* as the main consituents) as secondary and alluvial woodland pollen response levels also increase. A contraction of the pasture (from 64.3% to 49.2%) and culture-steppe group (from 6.2% to 3.2%) also occurs, in tandem with the above phenomena. Annual herbaceous types at this time include *Polygonum convolvulus* (0.8%) and *Centaurea cyanus* (0.8%). Other herbaceous taxa occurring within this "zone" include *Polygonum aviculare* (4.8%) and *Chenopodium* (4.0%).

Zone 10: (300 to 280 cm): in sedimentological terms, no change is registered in this zone. In palynological terms, the response levels of the saccate group and the *Cyperaceae* taxon remain relatively low (32.8% to 42.6% and 1.3% to 21.0% respectively) as A.L.P.C. remains high. Occasional appearances by *Nymphaea* are also notable. Also, a rational representation of first *Hordeum* and then *Triticum* is achieved in this zone (values vary between 0.6% and 0.7%). *Humulus* is a further element of the arable group which can be observed to obtain a rational representation(values vary between 0.6% and 0.7%), while an early find of *Secale cerealia* is interesting (1.3%). Weed species of further note encountered include *Polygonum convolvulus* (at 3.2%, black bindweed reaches its absolute maximum), *Agrostemma githago* and *Centaurea cyanus*. Like the preceding phase, a high representation is achieved by both *Polygonum aviculare* (1.8% to 4.2%) and *Chenopodium* (up to 5.2%), while *Plantago major* and *Plantago media* are also achieve (in tandem) a rational representation. Significantly, the pastoral group produces very high values of aster pollen. Umbellifers are also extensively represented, while pollen of the wet pasture group rises to 73.9% by the end of this phase (cf. 49.2% in Zone 9). Finally, pollen of the primary woodland group declines from 21.4% to 10.9%.

Zone 11: (276 to 272 cm): telmatic pollen representation reaches an absolute minimum (with *Cyperaceae* values ranging between 2.2% and 2.3% only). Saccate pollen values are also low (with *Pinus* values ranging between 9.8% and 13.4%). Conversely, pasture group pollen representation (comprised primarily of *Gramineae* and *Asteraceae*) attains an absolute site maximum (84.4%). A decline of primary woodland pollen occurs (falling from 10.9 to 6.4%), while secondary and alluvial woodland groups decline from 5.2 to 2.9 and 4.6 to 1.7% respectively. *Humulus* continues to be represented in this period (at 0.6%), although representation by weeds is declining.

Zone 12: (268 to 260 cm): in sedimentological terms, no change is registered in this zone. In palynological terms, (high) A.L.P.C. remains constant, saccates increase significantly towards the end of this phase, from 15% to 34% (reflecting moderately lower water levels). More emphatic is a rise of semi-aquatic *Typha latifolia* and *T. angustafolia.* The latter in tandem rise from 0.0% to 19.3% in this zone. Weed pollen is represented sequentially first by *Polygonum convolvulus*, then *Polygonum aviculare* and finally by *Polygonum persecaria* in trace quantities. *Polygonum viviparum* also becomes important towards the end of this zone (2.1%). The pasture pollen group falls from 84.4 to 66.7%, while the pollen response levels of woodland pollen groups rise. The primary woodland pollen group attains composite values of 8.7% (cf. 4.5% at the terminus of Zone 11). Secondary and alluvial woodland groups also rise respectively from 2.9% to 4.7% and 1.7% to 5.3%.

Zone 13: (250 cm): in sedimentological terms, a primarily siliceous substrate with humic detritus continues to characterise this zone. Primary woodland pollen also rises to 25.6% (*Quercus* attains values of 14.0%, *Fagus*, 10.5%), while secondary and alluvial woodland groups rise to 5.8% (combined *Betula*, *Corylus* et al.) and 9.3% (entirely of *Salix*) respectively. Herbaceous pollen types represented at this time include *Polygonum aviculare*, *Polygonum persecaria, Adonis aestiovalis, Scleranthus* and *Chenopodium.* Of these pollen taxa, the representation by *Scleranthus* is quite significant (12.1%). However, altogether, the pastoral pollen group as a whole declines from 66.7% to 31.4%.

Zone 14: (246 to 200 cm): in sedimentological terms, there is an emergence of more telmatic conditions as reflected in a high proportion of detrital peat deposited. In palynological terms, high levels of saccate, semi-aquatic and riverbank pollen are maintained throughout the zone. *Typha angustafolia* in particular attains a high of 24.6%, while *Pinus* rises to a zonal maximum of 140.4% of A.L.P. As the primary woodland pollen group falls to 9.6%, a rise occurs in the combined pollen values of the pasture (to 44.7%) and secondary woodland (to 13.8%) groups. There is only a sporadic representation by *Humulus* (maximally, 1.1%), *Triticum* (maximally, 2.1%), *Secale cerealia* (maximally, 1.1%) and *Cerealia* (maximally, 0.9%), with high (co-varying) values of *Polygonum aviculare* and *Chenopodium* Other herbaceous types represented include *Ranunculaceae* (to 3.2%) and *Vicia cracca* (near-rational at 1.0 to 1.1% levels). At 212 cm, *Triticum* reaches its La Tène Age maximum (of 2.1%), along with maxima of the weeds *Centaurea cyanus* (2.1%), *Scleranthus* (2.1%), *Polygonum aviculare* (8.5%) and *Chenopodium* (10.6%) in the same level.

Zone 15: (196 to 192 cm): in sedimentological terms, detrital peats are formed in a substrate of silt and *substantia humosa*. Saccate, semi-aquatic and riverbank pollen groups (which had been declining during the latest part of the La Tène period) rise in pollen response levels. *Pinus* thus rises to 176.9%, while *Abies* registers a rise to 92.3%, while *Typha angustafolia* attains a high of 24.6%. Primary woodland also rises from 11.6 to 28.6% during this period (*Quercus* to 12.2%, *Fagus* to 16.3%), while the secondary woodland group peaks at 15.4% (entirely of *Betula*) at 196 cm, but then declines to 2.0% at 192 cm. During this time, herbaceous pollen declines, save for *Artemisia* which attains an absolute maximum of 15.4% at 196 cm. A reduced representation by asters and a rise of *Plantago lanceolata* is also notable.

Zone 16: (188 to 168 cm): in sedimentological terms, no change is registered in this zone. In palynological terms, somewhat oscillatory peaks in semi-aquatic and riverbank pollen are expressed, although saccate pollen representation remains relatively low. Importantly, there is a rational representation of *Secale cerealia* and *Hordeum*, *Triticum*, *Cerealia* and *Humulus* (these comprise up to 6.5% of A.L.P. *en toto*). Other prominent herbaceous elements represented include *Galium* (to 11.3%), *Polygonum aviculare* (to 5.6%), *Polygonum persecaria*, *Polygonum convolvulus* (to 2.3%), *Scleranthus*, *Artemisia*, *Calluna vulgaris*, *Centaurea nigra* and *Centaurea scabiosa*. The pasture pollen group also rises (to 64.4%) at this time, although asters are no longer a most prominent member of this. Rather, the pastoral assemblage is led by *Plantago lanceolata*. Primary woodland group values vary between 7.8% and 19.4% during this period, the pollen of which is comprised of (firstly) *Fagus* and (then) *Quercus*.

Zone 17: (164 to 150 cm): in sedimentological terms there are no major changes in comparison with the earlier period. In palynological terms, there is expansion of the alluvial woodland group (from 1.8 to 8.2%), while combined values of *Cerealia*, *Hordeum* and *Secale cerealia* decline from 6.5% to 1.1%. However, of the pastoral flora, periodic maxima of *Trifolium* and the *Ranunculaceae* are notable. Positive responses in saccate and semi-aquatic pollen occur during the middle part of this pollen zone. Primary woodland values remain largely unchanged in comparison with those of the prior zone, however.

Zone 18: (146 to 130 cm): a major sedimentary change occurs during the Late 6th to Early 8th

Centuries AD, with the first deposit of substantial quantities of reduced clays admixed with silt (this is the lower limit of the upper main sedimentary zone). Palynologically, *Secale cerealia* reaches its absolute maximum of 10.4% at 138 cm, closely mirrored in a rise of the herbaceous *Centaurea cyanus*. Respecting other herbaceous types; there is a fall of *Plantago lanceolata* and a rise of *Compositae liguliflorae*. The composite primary woodland pollen group also reaches its lowest ebb to date (to a 2.9% response level *en toto*, with trace quantities of *Quercus* and *Fagus*).

Zone 19: (126 cm): this zone contains only coarser sands lacking in pollen.

Zone 20: (122 to 118 cm): total *Cerealia*, *Hordeum*, *Triticum* and *Secale cerealia* within this zone achieve sustained heights of *circa* 9.8%. Tree pollen values within this zone are very low (primary woodland as a group comprises between 1.6% and 2.2% of A.L.P.). The general character of sediments and pollen spectra in this zone is similar to those of the pre-flood event Zone 18.

Zone 21: (110 cm): in sedimentary terms, a minor change in stratigraphy is discernible in the reduced clay content of sediments. Importantly, cereal pollen representation falls to 1.8%.

Zone 22: (105 to 77 cm): the representation by herbaceous pollen is very high, and that of deciduous tree pollen very low in this zone. The pollen representation of the group of *Cerealia*, *Hordeum*, *Triticum* and *Secale cerealia* within this zone varies, but culminates (at 77 cm) at 15.3%, an absolute maximum for this group. *Picea* values rise at the terminus of this zone (to 33.9% of A.L.P.).

Vranský potok: past and recent archaeological investigations

Archaeological investigations at Vranský potok began before the last world war with the collecting activities of a local avocational, F. Vobr. Vobr subsequently communicated his finds to A. Knor of the Archaeological Institute, whose excavations and archives comprise the primary data base for Eneolithic settlement in the basin. These excavations by Knor focus principally on Řivnáč Culture fortified sites in the Parish of Vraný (e.g., cf. Fig. 86). This unsystematic record has been recently enhanced through the methodical field-walking conducted by M. Kuna and others (cf. Figs. 38-45).

As part of a project of the Archaeological Institute, Kuna has attempted the first systematic surface survey of ancient settlement in Bohemia, focusing on exposed plough-soils. The archaeologic methodology of this survey consists of collecting pottery sherds by field-walking alternate 100 m wide transects (with 20 m intervals between surveyors) across primary arable tracts as defined by slope aspect, soil conditions and distance from available water sources (cf. Chapter 2 and the discussion of ecologically circumscribed cells employed by Kuna at Únětický potok). These systematic finds are expressed quantitatively as four modal values indicated by differential stippling values in Figures 38-45, equating to (1) one, (2) two, (3) three and (4) four to twenty pottery finds recovered per definable period per $(100 \text{ m})^2$ of survey area respectively. Highly concentrated pottery finds are thus given a low relative weighting.

A palynological test as to the representivity of the systematic and unsystematic archaeological data-bases in terms of actual prehistoric settlement intensity vis à vis the history of anthropogenic impact on vegetation at Vranský potok (see figure in back jacket, Figs. 38-46 and Table 6.3) will be provided in a following section of this chapter, while a full account of this comparative settlement archaeological framework now follows. Provisional associations of archaeological material with particular pollen zones are indicated ("cf.").

Vranský potok: interpretation of palynological data set and comparison ("cf.") with local archaeological occupational evidence

Interpretation of Zone 1: sedimentary characteristics and palynological change would appear to be a result of high water tables consequent upon the first wide-spread disturbance of the woodland (which also reduces evapo-transpiration). Semi-reduced sediments consist mostly of clay, with some silt. The reduction of evapo-transpiration raises water-tables and reduces sediment oxidation. Base-level conditions for sedimentation, which also provides a matrix for pollen deposition and subsequent preservation, are established at this time, however, water tables are still low compared to subsequent zones, as reflected in high saccate pollen and a low A.L.P.C. (Figs. 32-33). It seems quite possible that anthropogenic factors are in part responsible for possible high water-tables following slope denudation, after high primary cultivation values of 3.3% expressed at 416 cm.

Cf. archaeology to Zone 1: Earlier (Pre-Bronze Age?) cultivation phase (424 to 412 cm): Vobr's and Knor's (unsystematic) Eneolithic finds at Vranský potok are quite extensive, and stem primarily from the Funnel Beaker and Řivnáč Cultures (Fig. 38). Early Funnel Beaker pottery is first reported by Vobr at Ostrov, where there is evidence for burials in a settlement pits like coeval finds at Libkovice and Malé Březno (in North Bohemia). Further Funnel Beaker pottery finds are reported by Vobr near the residence of a Mr. Katouše (a Vraný farmer), thus a low concentration of earlier Eneolithic material is to be found around the bounds of the present-day village. Subsequent Řivnáč material appears in three places overlooking the gorge, as discovered by Knor. A further layer of Řivnác cultural material with settlement pits occurs at Nad Splávem. The contents of these culture pits suggest an earlier Řivnáč occupation, although more extensive settlement material was found at the "Hradiště" of Vraný, a fortified settlement extending over one hectare. Within the excavated area behind the palisade (ca. 600 m^2), three huts were uncovered by Knor after the last world war. It would appear that the entire settlement might have contained up to 50 such huts, occupied during the later Řivnáč Culture period (Globular Amphora material was also found). East of Hradiště at "Žižkaberk", further Řivnáč material was found by Knor, while potentially belonging to either the Funnel Beaker or Řivnáč Culture are six polished stone celts, found in unspecified fields by Vobr and Knor. In contrast to these numerous unsystematic finds, systematic field-walking produced but a single pottery sherd, probably belonging to the Řivnáč Culture, north of Hradiště.

Assuming that rates of deposition prior to 405 cm (a main stratigraphic zonal break) are much lower than that suggested by subsequent radio-carbon chronology, this initial cultivation phase can be hypothetically dated to the Eneolithic. This presumes an extrapolated date of (ca.) 2100 cal. BC at 405 cm, with an estimated rate of deposition of 50+ years per cm below this main zonal threshold. The earliest alluviation might reflect accumulation of silt resulting from sheet-wash following the introduction of traction-ard agriculture into the area, perhaps at the time of the Funnel Beaker Culture. It is likely that the substantial Řivnáč settlement in the proximate part of the basin is responsible for the zonal peak of cultivation, when local populations might have numbered upwards of 100 individuals. Bearing in mind the limits of circular reasoning, this phase might be correlated with an apparent increase in local population in the Middle Eneolithic.

Interpretation of Zone 2: semi-reduced sediments consist mostly of clay silt, after which slow sedimentation under reduced conditions are inferred. Pollen concentration is low under low water tables within this zone. A local expansion of alder (site absolute maximum) is clearly indicated, alongside telmatic sedges. The colonization of the inundation zone by these telmatic floral elements is a likely antecedent to a local water-table lowering, perhaps after a revegetation of adjacent slopes (Figs, 32-33). This might take place in the context of a reduction in regional settlement intensity after the major Řivnáč occupation.

Cf. archaeology to Zone 2: Later (Pre-Bronze Age?) recession (408 to 404 cm): material of the Late Eneolithic cultures appears as isolated finds in different parts of the basin of Vranský potok (Fig. 38). Only 100 m south-east of the bore site, Corded Ware pottery was recently discovered by L. Peške as part of a colluvial deposit below the steep southern terrace of Vranský potok. Otherwise, the Corded Ware Culture is reflected in finds by Vobr and Knor of a hammer-axe, two stone mace-heads and a long flint axe. It is likely that the former three items are symbolic only, stemming from graves, although the find spots of these are unspecified in archives. Later Bell Beaker Culture open-settlement is also attested at Hradiště. No systematic field-walking finds are reported from this Late Eneolithic period, although Corded Ware and Bell Beaker pottery can be identified on the basis of tiny sherds.

A correlation of the later P.A.Z. 2 at the boundary of the main stratigraphic interface with the immediate pre-Bronze Age is tenuous, although an extrapolated Late Eneolithic date is postulated. If it is possible to view a reduced level of human impact on flora as reflecting lower local population levels, Peške's finds of Corded Ware sherds only 100 m from the bore site would make the expression of poverty of syn-anthropic pollen contrary to primary (spatial) bias.

Interpretation of Zone 3: the semi-aquatic and riverbank pollen components seem to be responding in complex ways, both to changes in taphonomy (decreasing relative representation), and also a significant expansion of their range (increasing absolute production) as early human impacts on vegetation feed into the local hydrological cycle (Figs. 32 and 34). A reappearance of cultivation is certainly reflected in flax pollen found in this zone, in addition to an array of arable weeds including *Polygonum aviculare*, *Chenopodium* and *Artemisia*. Dry soil conditions, promoted perhaps by deforestation and arable agricultrure, are reflected furthermore in the appearance of *Centaurea nigra* and *C. scabiosa*.

Cf. archaeology to Zone 3: Earlier Bronze Age (earlier phase) cultivation phase (400 to 384 cm): the Early Bronze Age archaeology includes both funerary and settlement material (Fig. 39). Of Early Únětice date is a grave reported by Vobr, from a field once owned by Mr. Katouše (exact locality now unknown), while near Ostrov at "Pod Bránou", a further grave hints at the presence of an Early Bronze Age site within the modern village. Knor also discovered settlement material of the Únětice Culture at Hradiště. Systematic field-walking evidence is extensive in this period, when four (100 m)^2 quadrants at "Za Zámkem" produce one to three pottery sherds of Early to Middle Bronze Age date. Pottery of Late Únětice date (Moucha Phase 6) is also prominent here, with three (100 m)^2 quadrants producing one to two sherds (Fig. 40). Contrary to primary (spatial) bias, cultivation indicators increase even as settlements are removed from the bore site. A poverty of cultigens is suggestive, together with a perennial-dominant weed assemblage, of a less than intensive agrarian regime in the earlier Bronze Age.

Interpretation of Zone 4: lower hydrological levels are evidenced in enhanced response levels of saccate, semi-aquatic and riverbank pollen. It is likely that a high interception of surface and ground water is occurring under conditions of greater aforestation with very little arable agriculture (Figs. 32 and 35). This aforestation is directly reflected palynologically in absolute maxima of shade-tolerant *Melampyrum* and arboreal *Quercus*, as well as by a complete poverty of arable weeds.

Cf. archaeology to Zone 4: Earlier Bronze Age (later phase) recession (380 to 375 cm): the archaeology of this period is problematical in view of difficulties in distinguishing between the Early and Middle Bronze Age settlement pottery. However, of certain Tumulus date is a weaponry hoard-find with bronzes assignable to Reinecke Bronze Age B, from an unlocalised find spot near Vraný (Fig. 39). It is likely that settlement continues in the western part of the basin, even as the long-term settlement of Vraný-Hradiště is finally abandoned.

Interpretation of Zone 5: in accord with the hypothesis of the alluvial extension of the Neves-effect, (floating) saccate pollen decreases of *circa* 80% occur in tandem with a flooding-out of semi-aquatic pollen types (which decline to less than 1%). Notably, a sedimentology of reduced silts also provides independent evidence for high water tables (Fig. 31). Further affirming the anthropogenic basis of local hydrological change, the A.L.P. spectrum presents a picture of cultivation and deforestation. Once again, a model of slope vegetation denudation and lower water interception (and evapo-transpiration) is invoked (Figs. 32 and 35). Annuals are significantly represented in this zone, while combined primary cultivation indicators increase to 2.0%. This is the highest level of cultivation evidenced since Zone 1 times. A drying of soils, following clearance and agriculture seems to be reflected in a expansion of steppic floral elements. In temporal terms, these major floral changes occur over three to four human generations.

Cf. archaeology to Zone 5: Early Knovíz extensive cultivation phase (372 to 356 cm): the first (unsystematic) Knovíz finds by Vobr were made near Ostrov at "Pod Bránou". Knovíz ceramics in a garden on the south side of Vraný are also embedded in "a thick settlement layer", although its extent is undetermined. More extensive are systematic field-walking finds of Knovíz age, expressed as five discrete concentrations of up to 20 pottery sherds per $(100\ m)^2$ quadrant from two places near the chapel at "Za Zámkem", from one quadrant only 200 m south of the bore site and from two places north of the Eneolithic and Early Bronze Age settlement zone of Vranský potok (Fig. 41). Compared to field-walking finds of earlier epochs, these Early Urnfield finds represent much denser concentrations, although it is unlikely that all "sites" are simultaneously occupied (should two be so occupied, a local population of more than 200 might be reconstructed, assuming that these sites represent individual villages). It is important to recapitulate that higher levels of cultivation are achieved very early in the Urnfield sequence.

Interpretation of Zone 6: this variable pollen zone designated as a "cyclical cultivation phase" presents a complicated pattern of phase-lag relationships between the response of pollen groups, changes in hydrology and land-use. In sedimentology, this zone is suggestive of lower hydrological levels, although some flux in this parameter in indicated in the *Cyperaceae* curve (stable inverse relationships might reflect more-enduring land-use phases, cf. Figs. 31-32 and Fig. 35). The cultivation cycles apparent in this zone might reflect rotations in settlement location as well as oscillations of micro-regional settlement intensity, with such rotations expressing a periodicity of two to three human generations after (^{14}C) sedimentation rates. A similar settlement dynamic in "less optimal" farming zones has been demonstrated archaeologically by Smrž at settlement sites of the Knovíz and Štítary Cultures in the Lužický potok basin of Northwest Bohemia (cf. Figs. 1-3 and 41).[21]

Cf. archaeology to Zone 6: Late Knovíz cyclical cultivation phase (352 to 336 cm): it is inferred after the geo-botanical data (but not independently demonstrated by a fine chronological resolution of settlement material) that a smaller number of Knovíz "sites" are simultaneously occupied in the Vranský potok basin during this zonal period. Under this sub-hypothesis, it may be supposed that moderate, out-of-phase indicators of farming, deforestation and enhanced palaeo-hydrology reflect not absolute changes in settlement density, but rather changes in intra-basin settlement location. For instance, while local water levels are higher, but syn-anthropic pollen lower, it may be that Knovíz farmers are settled in the western part of the basin, weakening the arable pollen response while producing a higher water table down-stream of their agricultural settlement through the perturbation of soil and root structures. Conversely, proximate agrarian

21 Smrž 1987a, b

settlement immediately east of the bore site may impact down-stream water tables beyond a local effect, although a discernible syn-anthropic pollen response to local cultivation is still produced.

Interpretation of Zone 7: initially higher water tables give rise to lower ones out-of-phase with lowered intensities of agricultural settlement as expressed in terms of primary cultivation. The latter indicators are maintained at about the level of Zone 6 (cf. Figs. 31-32 and Fig. 35). A significant level of aforestation is indicated within the Late Bronze Age sequence, as primary woodland expands emphatically. In terms of pollen representation by *Fagus* and *Quercus*, this increase in the order of 250% must reflect a substantial, basin-wide aforestation.

Cf. archaeology to Zone 7: Knovíz-Štítary transitional recession (332 to 324 cm): empirically, this agricultural recession is archaeologically "invisible" after surface pottery chronology. It should be noted; however, that Bouzek has proposed a minimum oscillation in climate coeval with Hallstatt B1 in Bohemia, analogous to climate-driven agrarian settlement transforms of the Late Bronze Age period as proposed by Bouzek and Pavúk (et al.) in Central Europe (cf. for example Figs. 105-7, cf. also discussion of climate evidence of Hallstatt B1 date in Chapter 4).[22]

Interpretation of Zone 8: once again, direct sedimentological and indirect pollen taphonomical evidence for higher water tables occurs together with evidence for a more intensive agricultural settlement of latest or terminal Bronze Age date (Figs. 32 and 34). The reduction of both alluvial and primary woodland is significant, and the mixed-oak woodland itself declines as a group to 11.6%. Conversely, primary cultivation indicators are very significant, and attain a 2.3% during this period. Possible winter cultivation may be indicated in the appearance of barley pollen, but this is as yet indeterminate. Certain weed species represented, particularly *Agrostemma githago* and *Centaurea cyanus*, support the latter hypothesis.

Cf. archaeology to Zone 8: Štítary extensive cultivation phase (320 to 308 cm): this extensive cultivation phase is represented by extensive field-walking finds. Of certain Štítary date are finds of one to twenty pottery sherds from five (100 m)^2 quadrants in two loose clusters: one at "Za Zámkem" in the west and one immediately south of the bore site on the first terrace of the Vranský potok (Fig. 42). Given the continuity of syn-anthropic pollen response, enhanced hydrology and higher human impact inferred after sedimentology, it is likely that both "clusters" are occupied during this phase. Should these clusters represent somewhat larger villages than those of the Knovíz Culture (given a positive, quasi-linear association between extent of settlement remains and intensity of agricultural settlement supported in Table 6.3 below), a local

22 Bouzek n.d., Pavúk et al. n.d., cf. v. den Bogaard et al. 1999

population of 200 to 300 is estimated.

Interpretation of Zone 9: given potential expectations of a significant agricultural recession at the beginning of the Iron Age after settlement data (see Chapters 2 and 11, cf. Fig. 8 esp.), this spectrum presents an ambiguous picture of shorter term change in land-use patterns which cannot be interpreted in terms of a clear decline in settlement intensity. In essence, this zonal designation is of dubious statistical value, and is introduced for comparative purposes with the archaeological record. Conceptually, Zones 8-10 should be viewed as a vegetation continuum. Future publication of the site data-base will reflect this fact.

Cf. archaeology to Zone 9: Hallstatt C (?) transitional phase (304 cm): although it is not always possible to specifically distinguish pottery of Hallstatt C date from surface finds, the continuity of Hallstatt C settlement in the Vranský potok basin can be demonstrated in unsystematic finds. In reference to archival notes of L. Horáková, diagnostic sherds of Bylany Culture date occur south-west of the village church in the eastern part of "Za Zámkem", near graphite pottery concentrations of Hallstatt B to D date found by field-walking. It is possible that Hallstatt C pottery comprises part of this undifferentiated mass of ploughed-up surface material (Fig. 43.

Interpretation of Zone 10: given the tendency of asters to flower profusely in cut (as opposed to grazed) meadows, this aster rise may be an indirect reflection of the introduction of the iron sickle during the Late Hallstatt Age. The first appearance of *Secale cerealia* is notable. Alongside further (winter-arable weed) species such as *Polygonum convolvulus*, *Agrostemma githago* and *Centaurea cyanus*, winter cultivation in the Early Iron Age may be reflected in the palynological evidence of Zones 8-10.

Cf. archaeology to Zone 10: Early Iron Age cultivation phase (300 to 280 cm): a continuity of farming settlement represented in the general Hallstatt pottery distribution (Fig. 43). It might be presumed that a substantial proportion of these finds belong also to this phase. The palynological evidence cited above is also suggestive of a moderate settlement expansion.

Interpretation of Zone 11 : cultivation indicators are indicative of a non-intensive agriculture, although a contraction of woodland during this period might reflect extensive land-use practice. Aster pollen and pastoral pollen in general continue to register high response levels. A high level of local pastoral land-use might be indicated in this.

Cf. archaeology to Zone 11: Late Hallstatt extensive cultivation phase (276 to 272 cm): this settlement phase is correlated with a discrete Late Hallstatt pottery concentration 200 m south of the bore site, consisting of three adjacent quadrants with between one and twenty pottery sherds

(Fig. 43). Also, occupation at Za Zámkem continues. From this evidence, we might presume the existence of two discrete villages with (ca.) 200 inhabitants in the basin (cf. Table 11.1). The peak of Early Iron Age cultivation reflects a mixed agriculture more pastoral than that of the Štítary economy, with the possible addition of hay-meadow harvesting for winter fodder.

Interpretation of Zone 12: a relaxation of extensive cultivation is experienced in this zone with an inferred fall of the water table. Telmatics are gradually encroaching on bore site as water tables fall, while the perennial composition of the weed flora is also suggestive of a more relaxed agricultural intensity. In general, the pollen flora supports a hypothesis of reduced human impact on the environment in the period of Zone 12 (cf. Figs. 32, 35). An expansion of woodland and a contraction of pasture are indicated. Primary cultivation indicators are also of a very low order (maximally, 0.2%).

Cf. archaeology to Zone 12: Early La Tène cultivation phase (268 to 260 cm): it is likely that a general decline in local population transpires at this time, although continued settlement occurs in the immediate vicinity of the bore site. The decline in agricultural intensity as reflected in palynology thus takes place contrary to primary (spatial) bias, further affirming its reflection of wider micro-regional events.

Interpretation of Zone 13: hydrological levels continue to fall within this zone as reflected in singular peaks of saccate and semi-aquatic pollen. Basically, these floral indicators suggest a further terrestrial encroachment on the bore site (cf. Figs. 32, 35). Lower water-tables are most-likely a result of lower human impact after the slope denudation-revegetation model affirmed in multiple pollen zones at this site. Within this zone, a low-human impact regime appears to be one of a more pastoral mixed agriculture (after the proportion of biennial weeds represented).

Cf. archaeology to Zone 13: Middle La Tène recession (250 cm): this phase is represented archaeologically by finds of four bronze arm and neck rings of La Tène B date, from a woman's grave of uncertain locale. Given the paucity of settlement remains, it is probable that only dispersed hamlets remain in the micro-region (Fig. 44).

Interpretation of Zone 14: this latter acute sub-phase occurs with a further break in stratigraphy, where greater silt-deposition is suggestive of local high-water tables (cf. Figs. 32, 34). Generally, phase lags between initial impact on soil structure, hydrological flux and local vegetation might reflect localised rather than regional land-use change, when these pollen recruitment components are maintained at dynamic equilibrium. Primary woodland pollen declines during this period to 9.6%, while an a array of primary and secondary cultivation indicators occur at low values until the terminal spectrum, when *Polygonum aviculare* again rises to 8.5%, while *Chenopodium* rises to 10.6%. Primary cultivation indicators include *Humulus*, *Cerealia*, *Triticum* and *Secale cerealia.* Significant values of *Centaurea cyanus* (2.1%) with finds of rye might allude to a minor winter cultivation component to the arable regime.

Cf. archaeology to Zone 14: Later La Tène cyclical cultivation phase (246 to 200 cm): archaeological finds of the later La Tène include three sherds found by Vobr in an unnamed field by Vraný. Systematic field-walking by Kuna also discovered but a single quadrant containing two such La Tène sherds north of Žižkaberk. Altogether, this evidence is indicative of modest agricultural settlement (Fig. 44).

Interpretation of Zone 15: sedimentology and the responses of saccate, semi-aquatic and riverbank pollen groups are indicative of greater telmatic influence under a low water table, and perhaps, a low level of agricultural intensity (cf. Figs. 32, 35). An increase in primary woodland pollen to 28.6% during this period supports the latter inference, as does the general poverty of syn-anthropic pollen types.

Cf. archaeology to Zone 15: Early Roman Iron Age transitional recession (196 to 192 cm): recalling structural changes in regional settlement patterns emerging with the Roman Iron Age (cf. Figs. 9-10) at Vinořský potok, the geo-botanical expression of this same transitional period at Vranský potok might reflect fluctuations in hydrology following from lapsed land-use.

Interpretation of Zone 16: the saccate pollen response is suggestive of high water tables associated with a more intensive cultivation (cf. Figs. 32, 34). The high pollen response of primary cultivation indicators (6.5%, the highest level to-date) supports this inference. A wide variety of weeds are also encountered (*Galium*, *Polygonum aviculare*, *Polygonum persecaria*, *Polygonum convolvulus* and *Scleranthus*), indicating short fallows. A degree of winter cultivation may again be suspected during the period of this zone, while an increase in pasture to a 64.4% representation level is significant. It is interesting that *Plantago lanceolata* rather than asters are prominent in the latter flora (a cessation of hay-cutting and more direct grazing may be indicated). Primary woodland values remain relatively depressed during this period.

Cf. archaeology to Zone 16: Early Roman Iron Age intensive cultivation phase (188 to 168 cm): systematic field-walking reflects a very extensive settlement regime in finds of one to three Roman Iron Age pottery sherds from 19 quadrants dispersed throughout the basin (Fig. 45). Thus, extensive settlement evidence may be indicative of intensive cultivation. After archival photographs of older finds from these same fields, Kuna's pottery should date to the Early

Roman Iron Age primarily. Also dating from the period of the Marcomannic Wars is a single *denarius* of Marcus Aurelius, probably part of booty acquired from these AD 166-80 wars between native Germanics and Rome. It may be inferred from the general weed assemblage that intensive spring and limited winter cultivation characterises a regime where fallows are shorter than four years, as annual weeds exceed biennials and perennials for the first time.

Interpretation of Zone 17: high values of saccate and semi-aquatic pollen reflect low water levels associated with a relaxation of land-use regimes (which allow for a revegetation of slopes, cf. Figs. 32, 35). Primary cultivation thus falls from 6.5% to 1.1%. Rises in woodland pollen are restricted largely to taxa of the alluvial zone, however. A certain expansion of rosaceous "scrub" is notable during this period.

Cf. archaeology to Zone 17: Late Roman Iron Age (and Migration period) recession (164 to 150 cm): a further coin in Vobr's collection comes from the later Roman period, bearing a Byzantine inscription "Philip the father" (Fig. 45). In keeping with evidence for a general Bohemian decline in settlement intensity during the later Roman and Migration periods (see Chapter 12), cultivation indicators decline precipitously during this proto-historic period of tribal unrest. No further archaeological evidence (i.e., of Medieval or later date) will be considered in this section, although interpretations of final pollen zones are provided.

Interpretation of Zone 18: sedimentology is suggestive of poor sorting experienced as the fluvial system loses its competence to carry an increased sediment load. As such, low water levels relative to higher sedimentation rates are expressed in an initial rise in riverbank pollen, even as saccates and semi-aquatics are suppressed (cf. Figs. 31-32, 36). Notably, the latter are responding to "relative" rather than "true" hydrological levels as relative alluviation out-strips water-table changes. Higher rates of sediment input might be expected after the very intensive levels of primary cultivation experienced (*Secale cerealia* alone attains 10.4%). Very high values of *Centaurea cyanus* attest to a prevalence of winter cultivation during Early Slavonic times. No further field-walking data are available to the author for purposes of direct comparison, although surface finds from this period tend to be profuse on a general basis.

Interpretation of Zone 19: the deposition of coarse sands attests to a high-energy erosional event in the environs of the sampling site, due to the crossing of a new threshold of intensive cultivation which renders arable soils highly friable (Fig. 31).

Interpretation of Zone 20: a high rate of cereal representation (*Secale cerealia* at 9.8%), as well as extensive winter (*Centaurea cyanus*) weeds of cultivation imply a fallow much shorter than that enjoyed even in the Early Roman Iron Age, of perhaps only one or two years after the proportion of annual weeds. A return to composite-dominance in the pastoral group (now, *Compositae liguliflorae*) may be indicative of a return to hay-meadow mowing. As sediment load rises (leading to a sub-competent alluviation), saccate and semi-aquatic pollen behave as per low hydrological cycles (cf. Figs. 31-32, 36).

Interpretation of Zone 21: this zone perhaps reflects the increased competence of the stream with reduced sediment load Saccate, semi-aquatic and riverbank pollen begin to respond again to "true" rather than "relative" hydrological levels, indicative of a reduced sediment load. A fall in primary cultivation pollen here-in is very significant. This relative recession is concurrent with pastoralist Magyar incursions from the Hungarian Plain into Central Europe *circa* AD 900 (extrapolation of sedimentation rates based on radiocarbon dating place this zone at ca. AD 870). A coeval destruction of agrarian settlement is recorded also in Carolingian historical sources.

Interpretation of Zone 22: this zone would appear to reflect high population levels which may be fluctuating locally as indicated by cultivation values. Very high cultivation values encountered (up to 15.3% of A.L.P.) should be taken as a base-line percentage after which full utilization of the agricultural landscape may be inferred.

Vranský potok: a local negation of the Behaviouralist hypothesis

Before embarking on a detailed consideration of later prehistoric settlement history in Central Europe in later chapters, the author will first consider the micro-regional geo-botanical evidence from Vranský potok and in particular, its reflection of prehistoric settlement within this small, (ca.) 15 km^2 basin. This will involve a comparison of the actual settlement intensity reflected in human impact with reconstructed settlement intensity after archaeology. Should a strong positive relationship emerge between these two data bases, the representivity of the settlement archaeology will be affirmed. The systematic surface survey data here-in is quantified through time, using an index equation based on the extent and quantity of ceramic finds per century. Furthermore, after the field-work of M. Kuna, which focuses upon the relationship between surface pottery and sub-surface feature finds at Vinořský potok, greater weight is assigned to the find-extent parameter within this below equation.[23]

Index values of finds-quantity will thus follow directly the above (1-4) modes, equating to 1-

23 M. Kuna pers. comm., 1994, cf. Kuna 1998

4+ ceramic finds recovered per $(100\ m)^2$. The local settlement intensity index will thus be calculated as follows, where A = no. of survey quadrants with pottery finds, B = cumulative total of modal values of pottery finds and C = time in centuries represented by the cultural period as reflected in prehistoric pottery finds (note that the determination of cultivation levels in the Early-Middle Bronze Age and Věteřov Bronze Age is problematic due to limitations of dating, a consideration of the Eneolithic period is omitted here due to severe limitations):

$$\text{Local settlement intensity} = 2(A) + (B)/C$$

Comparative numbers of determinate (unsystematic) find-spots per century might also be compared to the systematic index and primary cultivation values for these same periods (see Table 6.3 below). These data indicate a strong correlation between relative settlement intensity after systematic survey data of Kuna and cultivation intensity after primary geo-botanical data, which is indicative of a local negation of the Behaviouralist hypothesis. Much weaker is the mutual correlation between unsystematic archaeologic data and these indices (cf. Figs. 38-45).

Table 6.3 Magnitude of local settlement and cultivation intensity at Vranský potok

Time period	Systematic index	Primary cultivation %	Other find-spots index
Early-Middle Bronze Age	2.9	0.0?	0.3
Věteřov Bronze Age	7.0	1.1?	1.3
Knovíz Urnfield	8.5	2.0	5.8
Štítary Urnfield	14.4	2.3	0.0
Late Hallstatt-Early La Tène	4.0	1.4	0.2
Middle-Late La Tène	1.1	0.0 (Middle)/2.1(Late)	0.0
Roman Iron Age	15.0	6.5	0.0

Vranský potok: general observations

The geo-botany and archaeology of Vranský potok establishes a mutually supportive record of palaeo-palynology, palaeo-hydrology and systematic settlement history. An interpretive method developed uses a dynamic equilibrium model linking palaeo-hydrology as reflected in pollen recruitment dynamics, changes in stratigraphy reflecting the same and terrestrial pollen evidence for prehistoric land-use, all compared with a systematic and uniformly diachronic data-base of micro-regional settlement archaeology. Limits of scale should be observed, as geo-botanical events at Vranský potok are influenced by prehistoric land-use within an area of only 15 km². This micro-region, although possessing rich if somewhat sandy soils, lies at a higher (+50-75 m) elevation than the primary settlement cells in the czernozem-rich lowlands nearer the River Elbe. Actually, less than half the surface area encompassed is covered by arable soils of the best variety. Because of its relatively peripheral position and higher relief, agriculture may have always been less-intensive at Vranský potok compared to that of the primary settlement cells.

Despite its "peripheral" position, the syn-anthropic pollen record at Vranský potok nonetheless experiences many of the settlement cycles which are discerned in the macro-regional context, regardless of primary (local) spatial bias (cf. Chapter 2). Certain ceramic typological problems in detecting recessionary events are further illustrated in the case of the Knovíz-Štítary recession. Conversely, when the macro-regional settlement archaeology (cf. Chapters 10 and 11) invites the probability of agricultural decline during the Hallstatt C stage, the local geo-botanical record is ambiguous as to the question of settlement contraction. Given the small area representing the primary pollen catchment (under 15 km²), this ambiguous syn-anthropic pollen response may reflect local quantum effects rather than macro-regional settlement tendencies (cf. the 15-30-50 km² "hypothesis"). Local archaeology and palynology are in agreement during the La Tène Iron Age, when field-walking finds and palynological signs of intensive cultivation are similarly scarce. La Tène cultivation then ceases with the transition to the Roman Iron Age period in a discernible agricultural recession (cf. transformation of settlement structure as discussed in Chapter 2 and shown in Fig. 10). Significantly, the Early Roman period witnesses the most intensive cultivation prior to the Early Middle Ages, in accord with the most extensive prehistoric settlement finds after systematic field-walking data. A break in inferred hay-cutting also occurs at this time, which may reflect a more extensive if less intensive agriculture.

Hay-cutting and the composite pollen response at Vranský potok

It has been postulated above that post- and pre-Roman hay-cutting in false oat-grass meadows is practised prior to *Compositae* flowering (late April to June).[24] This hypothesis finds support in an agrarian poem (ca. AD 848, cf. Zones 18-22) composed by the cleric, Wandelbert of Prüm, who sets the (Middle Rhineland) hay harvest in June, after the April to May flowering of most *Taraxicum* (cf. *Compositae liguliflorae*) species (cf. *C. liguliflorae* in Zones 15-22).[25] An earlier (Iron Age) composite maximum also occurs in *Aster* pollen (cf. *Aster* in Zones 10-14). It is possible that this Iron Age prominence of asters (which generally bloom in May to June) reflects a somewhat later seasonal hay-cutting period in the First Millennium BC, governed by a variant arable calendar with seasonal differences in the period of winter field preparation. Notably, the latter field preparation occurs in May during the period of 9th Century AD.

Vinoř and Vinořský potok (comparisons and contrasts with Vranský potok)

Central Bohemian pollen evidence in the basin of Vinořský potok derives from the Late Hallstatt archaeological site of Vinoř (at 239 m a.m.s.l.) in its middle reaches and the undated alluvial site at Vinořský potok (at ca. 184 m a.m.s.l.) in its lower reaches (Fig. 46). The basin of Vinořský potok contains rich agricultural soils, as reflected in the extent of czernozemic loess (25 of 50 km^2) within the basin. Its Bronze and Iron Age settlement is relatively intensive.[26] The alluvial site has been analysed on only a cursory basis due to time limitations, although even this limited comparative data set is of some value given the novel aspect of alluvial palynology in the Central European region as a whole.

The archaeological site of Vinoř was visited during 1995, as opportunities for pollen studies were presented by the extension of a utility ditch within the village (Fig. 47). Two storage pits (Features 10 and 11) were encountered, both cut to a depth of (ca.) 1.5 m below the prefsent surface Figs. 48-9). It was evident from the inter-digitated profile of Feature 11 that in-fill had been rapid. The relative preservation of basal organic material in Feature 11 also produced an oxidising discoloration upon exposure to air. This feature contains perfectly preserved pollen (in basal Layer 21). The in-fill of Feature 10 had proceeded more-slowly, although here too pollen was well-preserved (in Layer 4). Pottery finds from both features are indicative of an Early Iron Age date, with a large body sherd from Feature 11 placing this pit within the Hallstatt

24 Ellenberg 1988, 1991

25 Butzer 1993

26 Cf. Kuna 1991, Dresslerová 1995a, 1995

C2 stage of the Early Iron Age. Feature 10 produces pottery of Late Hallstatt (D) date.

Spectra from Features 10 and 11 reflect an increase in agricultural intensity during the course of the Early Iron Age, within the context of a largely open environment (Fig. 50). During Hallstatt C2, the open environment is primarily pastoral, as indicated in an abundance of *Gramineae* (36%), *Compositae lig.* (33.3%), *Asteraceae* (2.7%), *Ranunculaceae* (2.0%) and *Mentha* (0.7%), with potential over-representation by insect-pollinated types. Importantly, very insubstantial quantities of primary (at 2.0%) and alluvial (at 0.7%) woodland are suggestive of an entirely cleared landscape within a few hundred metres of the sampling site. Dresslerová's hypothetical extensive secondary woodland reconstructed for the basin is thus highly dubious (cf. Chapter 13).[27] In spite of the wide expanses cleared about the Early Iron Age settlement of Vinoř, a poverty of primary cultivation is evidenced, as indicated by isolated cereals (0.7%) and arable weeds represented solely by *Scleranthus* (2.0%), although the fallow *Chenopodium* taxon comprises a significant 10.7% of T.L.P. at this time.

The Late Hallstatt vegetation at Vinoř reflects the resumption of a more-extensive agriculture, as reflected in quantities of wind-pollinated *Artemisia* (20.1%) and *Chenopodium* (47.7%). In view of the pollen analogues from Dalem, the predominance of these taxa must reflect land clearance in excess of a 500 m radius around the sampling site, particularly in view of the total absence of primary woodland indicators at this time. In addition to pasture, culture-steppe and very extensive wastes, Late Hallstatt primary cultivation is reflected in an array of weeds, primarily those of winter fields (*Centaurea cyanus* at 2.8%), a regime affirmed in substantial finds of *Secale cerealia* (1.5%). Extensive spring cultivation is also suggested by considerable quantities of *Triticum* (at 2.5%), while finds of general *Cerealia* also occur (0.6%). Presuming then that the area within 0.5 km of Late Hallstatt Vinoř consists primarily of wastes interspersed with arable fields (sown during spring and winter), it is likely that at least one quarter of this area lay under cultivation at any one time, otherwise true pasture would begin to form over much of the fallow. This is enough of a fallow, however, to prevent the dominance of annual weeds, a community largely restricted to *Centaurea cyanus*. It is possible then that the same fields were used for spring and winter crops in annual succession, encouraging this prevalence of *C. cyanus*. Within these provisions, the extent of arable agriculture within a half kilometre radius encompasses (minimally) some 20 hectares sown annually, sufficient to support a village population of more than (ca.) 100 inhabitants (cf. Table 11.1).

27 Cf. Dresslerová 1995b, pp. 155-60

Further study of the basin Vinořský potok was made possible from a 4.5 m alluvial core from near the confluence of Vinořský potok with the Elbe (cf. Figs. 46 and 51). Samples are now described:

406 cm: Light grey organic-rich clay (As3, Dh1) alluvium under moderate telmatic influence.
379 cm: Light grey-orange silt with trace sand (Ag 4, Ga+) alluvium under aquatic influence.
356 cm: Dark grey organic rich clay (As3, Dh1) alluvium under moderate telmatic influence.
351 cm: Dark brown silt with trace sand (Ag4, Ga+) alluvium under aquatic influence.

Constituent pollen spectra from these samples are now described and interpreted:

406 cm: Saccate pollen attains its absolute maximum of 125% (of A.L.P.) at this level, consisting of *Pinus* (64.4%), *Picea* (25%) and *Abies* (39.6%). Likewise, *Cyperaceae* form only a relatively minor component (8.3%). Mixed-oak woodland still comprises a significant aspect of the landscape, contributing 37.5% as comprised of *Quercus* (22.9%), *Fagus* (10.4%) and *Tilia* (4.2%). Significantly, alluvial woodland pollen is entirely lacking. An arable weed component is prominent (16.7%), consisting of the biennial *Polygonum persecaria* (14.6%) and the annual *Polygonum aviculare* (2.1%),. Cultivation is represented by *Hordeum* (2.1%).

Interpretation: from this spectrum, it would appear that local water-tables are high-enough to exclude excessive saccate and (local) *Cyperaceae* deposition, while fallows in the order of five years (allowing for the dominance of biennial weed species) are indicated after K.E. Behre.

379 cm: Saccate pollen declines to low levels (16.9%), while the mixed-oak woodland declines to 15.0%. An expansion of cultivation is demonstrated, along with a culture-steppe (8.9%) of *Centaurea nigra*, *Centaurea scabiosa*, *Calluna vulgaris* and *Artemisia*. Together with an increased variety of primary cultivation indicators (*Cannabaceae*, *Triticum*, *Hordeum* and *Cerealia* at 2.0%), arable weeds also effect a substantial increase (to 23.0%), comprised of *Polygonum aviculare* (12.2%) and *Polygonum persecaria* (8.5%) and the winter weed *Agrostemma githago* (0.9%).

Interpretation: from this spectrum, it may be presumed that water-tables have risen relative to the accretion surface at the bore site due to human impacts. The intensity of cultivation is certainly greater than that of any prehistoric cultivation phase at Vranský potok, while the proportion of annuals now suggests that fallows may have fallen to four years or less.

356 cm: saccates have recovered (to 66.7%) in this spectrum. Large tracts of open ground are still extant, comprised of pasture (30.2%), culture steppe (11.1%) and weeds of cultivation (28.6%). However, primary cultivation indicators are lacking.

Interpretation: this spectrum may reflect lower water levels, after higher saccate pollen.

351 cm: saccates decline to 64.4% while primary cultivation rise to1.4 %.

Interpretation: a recession of intensive cultivation during the prior level is reversed while a slight water table rise might be inferred after the saccate pollen response.

Affirming the extension of the Neves-effect to alluvial situations, the spectra from the telmatic layers (406 and 356 cm) at Vinořský potok reflect lower levels of primary cultivation in tandem with a stronger saccate response (low water-levels follow from increased evapo-transpiration with the regeneration of root systems). With increasing cultivation (379 and 351 cm), the de-stabilisation of root and soil structures and subsequently enhanced water-levels within the fluvial system reduce rates of saccate pollen representation. Responses by the already marginal riverbank and semi-aquatic communities are more muted, perhaps due to their local exclusion within this somewhat higher energy system (at 12 km from the watershed). Broadly speaking, the spectrum from (ca.) 4 m depth at Vinořský potok is comparable to spectra from (ca.) 3 m depth at Vranský potok. This chrono-metric inference suggests in turn that rates of erosion and accumulation of sediment are greater in the primary Bohemian settlement cells vis à vis those experienced in more peripheral agricultural areas such as Vranský potok.

Methodological review

Primary pollen studies from Hercynia are intended to reflect human impact on a climax mixed-oak woodland environment. Not all sites have proved suitable towards this end. For example, lake sediments extracted from Komořany in Northwest Bohemia have proved to be dominated by sub-montane flora derived from the Ore Mountains or local alder wetlands, and contain almost no syn-anthropic pollen. Another sequence from Bylany 1 in Central Bohemia is simply too early (pre-agricultural) to be of great methodological interest in this context.

Furthermore, four viable spectra from Konobrže are of local significance, although inferences can be made respecting an increasing intensity of prehistoric agriculture at sampled intervals, which grows from pastoral origins in the Eneolithic to a more extensive arable regime in the Late

Bronze Age, a pattern not out of keeping with data from the principal site. Limitations of the Konobrže data set will preclude its further consideration, however.

The principal site of Vranský potok provides more comprehensive insights into the history of agriculture in Hercynia, after high-density palynological, systematic settlement and inferred palaeo-hydrological data which will also provide a local test of the Behaviouralist hypothesis within Hercynia. Because of the dense sampling interval employed, the data set at Vranský potok provides an almost continuous record rather than isolated data points for comparison of natural and cultural events.

Limits of the principal site lie in its areal scope of micro-regional pollen catchment (ca. 15 km^2), which implies after the 15-30-50 km^2 hypothesis that syn-anthropic floral patterns registered need not be macro-regionally representative. Further empirical limits also lie in the short time-elapse between samples, which in some cases, confuses the interpretation of anthropogenic pollen components reacting to the same cultivation events (at different phase-lags). Thus, primary cultivation at year 0 will be expressed as arable weeds in years 0-2, as fallows in years 1-4 and as pasture or steppe in years 4-10+, prior to secondary and primary woodland regeneration at 10^1 year and 10^2 year time-scales respectively.

A local negation of the Behaviouralist hypothesis at Vranský potok indicates that settlement archaeology is relatively reflective of true settlement populations within its basin. Interpretations of surface sherd concentrations as villages or hamlets in the prior description of Vranský potok settlement history are thus supported by the positive association between sherd densities and actual agricultural intensity. More importantly, a general correlation between the density of settlement remains and intensity of agriculture would indicate that conclusions as to palaeo-demographic developments derived from settlement data are more likely to be reliable. Thus, a more detailed analysis of the settlement cycle in later prehistoric Central Europe will be made in Chapters 9-12. The demographic trends discerned in this cycle will then be compared to wider pollen data (including secondary sources) and the proxy climate history record towards general tests of the Behaviouralist and Climatic hypotheses respecting ancient agricultural adaptations. First, the cultural ecology of early farming will be examined in Chapter 8.

7. Primary Pannonian geo-botanical sites

Primary pollen sites described in this chapter are employed towards local or regional floral reconstructions of progressive steppe formation in the wake of intensive agricultural settlement or destructive (non-agrarian) human impacts in Pannonia (and the Hungarian Plain). Beginning in the Bronze Age, pollen spectra reflect a steppe development which attests to annual precipitation differentials of (ca.) minus 100 mm in the more continental Eastern Carpathian Basin (Fig. 18). Progressively, trans-Carpathian sites indicate a loss in local effective precipitation (L.E.P.) of (ca.) 1-200 mm *per annum* during the Early to Late Bronze Age, coeval with phases of intensive settlement to be reviewed in Chapter 10. Very low levels of precipitation are also recorded in Hallstatt D (1-2) in South Moravia at the northwestern periphery of the Carpathian Basin. These Late Hallstatt findings become significant once archaeological evidence for contemporary Vekerzug pastoralist incursions into Moravia are considered in Chapter 11. Also, the destructive influence of the Roman military activity in Moravia and Slovakia is recorded from four archaeological sites of the Marcomannic Wars (AD 166-180), based on pollen spectra from primary and secondary fills of fortification ditches of legionary encampments. Cassius Dio places this Early Roman pollen evidence into proto-historical context as considered in Chapter 12. The eight primary alluvial and archaeological pollen sites from the Pannonian zone discussed in this chapter are described as follows:

1. Včelínce in East Slovakia: a Bronze Age archaeological site with partially contemporaneous gleyed deposits (dated *via* ceramic chronology, Figs. 52-56).
2. Mýtna Nová Ves in West Slovakia: a Bronze Age grave with adjacent abbreviated alluvial sequence (grave is dated *via* bronze chronology, alluvial sequence relatively dated after archaeological spectrum, Figs. 57-58).
3. Vojkovice in South Moravia: an Early Iron Age grave (dated *via* ceramic chronology, Figs. 59-60, 63)
4. Pohořelice in South Moravia: an Early Iron Age archaeological site (dated *via* ceramic chronology, Figs. 61-3)
5. Mušov-Burgstall in South Moravia: a Roman base (dated after numismatic evidence, Figs. 64-66)
6. "V Pískách" in South Moravia: a Roman marching camp (relatively dated by associated

marching camps in the Mušov micro-region, Figs. 67-68)

7. Můžla Jurský Chlm in West Slovakia: a Roman marching camp (dated after Roman military artifacts, Figs. 69-73)
8. Radvaň nad Dunajom in West Slovakia: a Roman marching camp (dated after Roman military artifacts, Figs. 74-6)

Categories of floral communities employed at pollen sites in Pannonia and at Včelínce in the Eastern Carpathian Basin vary from those of Bohemia. Firstly, after 17th Century archives at Mikulov in South Moravia, *Abies* and *Picea* may inhabit low-lying and sheltered alluvial areas (e.g., near high terraces) as one aspect of a bi-modal adaptation incorporating areas of higher soil-moisture retention.[1] Secondly, *Chenopodium* (thought to represent *Ch. album* in more temperate regions) is placed with steppic elements and is differentiated by the term *"Chenopodiaceae"*.[2] Finally, because the *Compositae liguliflorae* in Pannonia also include halophytes, this taxon is also placed in the steppic class. As a rhizosphere precipitation of salts follows from excessive evaporation or changes in the water table, this taxon may have indicative value to conditions of soil exposure or woodland denudation as well as more xeric climates.

Včelínce

The Bronze Age settlement at Včelínce (170 m a.m.s.l.) in the valley of the Slaná in East Slovakia takes us beyond the eastern pale of the main study area, to the more xeric Eastern Carpathian Basin (Fig. 52). The site was explored on behalf of E. Marková of the Slovak Archaeological Institute in Nitra. Pollen analyses produced positive results in four spectra spanning the period before the Early Bronze Age until the earlier Late Bronze Age.

The earliest and latest sediments derive from gleys in the drainage ("Rybník") adjacent to the Early Bronze Age site (Figs. 53, 55). Sediments belonging to the Early Bronze Age Hatvan and Otomani Cultures derive from the deeper fills (Layers VI and V) of the outer fortification ditch of archaeological site of Včelínce (Fig. 54), where Marková first reported finds of <u>uncarbonised</u> wood macro-sub-fossils in its lowest (Kisapostag) level (Layer VII). It was thought that where such sub-fossils were preserved, ancient pollen would be also, due to anaerobic conditions

1 Cf. Opravil 1967

2 Hajnalová 1986

following from rapid in-filling.146

The excursion to the site was undertaken in order to retrieve samples from the lower fills of the outer ditch, using the site datum to locate this and a Hillier borer to retrieve these archaeologic sediments as well as water-logged gleys of the adjacent drainage for pollen analysis. By using the archaeologically dated spectra derived from the v-shaped ditch, it was hoped that relative ages might be assigned to these gleys.

Pollen percentages are calculated simply after T.L.P. (inclusive of *Pinus*, Fig. 56). Pollen taphonomy in gleys may be regarded as quasi-terrestrial, as true water-flow is not expected in such a low energy hydrological regime (thus the Neves-effect is not extended here). The release of clay may be dependent on sheet-wash, particularly that following from local land-use.

Although an intervening layer of gravels prevented penetration into the Kisapostag layer of the outer ditch (VII), samples for pollen analysis were retrieved from the Hatvan layer (VI), as well as the Early (V) and Late (IV) Hatvan-Otomani layers, at depths of 2.55, 2.40 and 1.90 m respectively. The rapid rate of in-fill of the former layers (VI and V) allowed for relatively good pollen preservation. Pollen from the upper layer (IV) was too badly degraded to allow for a reliable count to made. Slower rates of deposit in these upper fills have enabled progressive soil aeration and pollen degradation. Viable pollen spectra are now described.

The local vegetation picture of the Hatvan Culture (ca. 2100 cal. BC) is one of pasture (22.1%) and steppe (16.2%), punctuated by traces of deciduous (1.5%) and more substantive riparian woodland (5.9%), relative percentages of which are also modulated by a high proportion of *Pinus* (50.7%). The over-represented pine can be expected to form a park land-type vegetation in a relatively open steppe. Its high pollen productivity might also be conditioned by climate. The deciduous (secondary) woodland consists largely of *Betula*, without substantial traces of hard-woods, on which basis it must be assumed that the forest as such is relatively open. The prevailing pastoral vegetation is dominated by *Gramineae* with an addition of composites and plantains (*Asteraceae*, *Cirsium* and *Plantago lanceolata*). The already well-developed culture-steppe is represented by taxa such as *Artemisia*, *Compositae lig.*, *Chenopodiaceae*, *Centaurea nigra* and *Calluna vulgaris*. Cultivation within this landscape is reflected in wastes and weeds of winter cultivation (*Agrostemma githago*).

The local vegetation picture produced for the period of the Hatvan-Otomani Culture (ca. 1900 cal. BC) is one of pasture (33.5%) and higher values of steppe (28.7%), punctuated by woodland (4.3%) and alluvial woodland (2.4%), all modulated by lower values (23.8%) of *Pinus*.

It is unlikely that the higher proportion of combined pasture and steppe is significant. Mixed-oak woodland is reflected in trace quantities of *Quercus*, while the alluvial woodland is scarcely represented. In addition to steppe and pasture, there is more extensive cultivation, with *Cerealia* attaining 1.2% of T.L.P. at this time. The arable weeds of these fields suggest spring cultivation in the Early Bronze Age as represented by *Polygonum aviculare* (4.3%).

The adjacent borings into drainage gleys at Bore 4 by the Bronze Age site encountered large deposits of Kyjatice (ca. 1200 cal. BC) pottery at 1.4 m below the present surface. Gleys were retrieved from immediately below what appears to be an extensive Late Bronze Age colluvium (also encountered in adjacent Bore 3), and subsequently subjected to pollen analysis. With a minimum limiting date provided by over-lying Kyjatice pottery, the spectrum from Bore 4 reflects more-steppic conditions during the earlier Urnfield period, with high soil temperatures probably inducing a low *Pinus* response (3.5%). The culture-steppe now expands to 51.0%, as reflected by the (halophytic) *Compositae lig.* type, as well as dry-heath vegetation (*Calluna vulgaris*). Cereal cultivation is significant, as registered by general *Cerealia* (1.4%) and the *Triticum*-type (0.7%). Arable weeds are represented by types of both spring (*Polygonum aviculare*) and winter (*Agrostemma githago*) fields, from which a development of the agrarian regime may be inferred, a regime which parcels-out cultivation throughout the growing season.

An undated *substantia-humosa*-rich gleyed deposit was recovered at a similar depth (1.4 m prior to modern excavation) from Bore 1, some 200 m upstream along the Rybník drainage. The Bore 1 spectrum reflects highly temperate conditions, with a moderately high contribution by *Pinus* (27.1%), a very strong pollen response by *Betula* (30.3%) and a primary woodland represented by traces of both *Quercus* and *Carpinus*. Alluvial woodland is also significantly represented by *Salix* in the lower flood reaches (6.9%), while the appearance of butterwort (*Pingulicula*) is also indicative of wetter local environments. Although culture-steppe elements occur, these persist in a more aforested environment containing trace weeds of cultivation or archaeophytes (*Agrostemma githago*, *Scleranthus*, *Rumex acetosella*, *Polygonum aviculare* and *Polygonum persecaria*). Given the depth of the Bore 1 sample (in the upper reaches of the drainage), its age must certainly be older than that of the Kyjatice colluvium. A weak (Bore 1) development of the steppe also suggests a date prior to the Early Bronze Age.

Palaeo-precipitation inferred after pollen response surface and proxy-palaeo-temperature data

Employing two-dimensional (mean July temperature and annual precipitation) pollen response surfaces derived by Bartlein (et al.) for *Pinus*, *Betula* and the prairie-forb component (culture-steppe), together with ^{18}O fractionation data from the South Polish (precipitation-dependent) tufas, a provisional attempt to reconstruct (effective local) palaeo-precipitation levels is made on the basis of pollen and isotopic data sources. Using the fractionation data to derive palaeo-temperature variations from the modern (mid-summer) mean, this establishes a periodic constant (x-intercept temperature-dimension) against which pollen response surfaces are compared to estimate approximate levels of palaeo-precipitation.[3] The constant of mean July temperature is established within an error band as defined by the statistical variation in the ^{18}O chronometry and potential deforestation effects on ambient water temperatures of tufa precipitation. Because the vegetation at Včelínce has been modified by human activities, these reconstructions may reflect modified local soil conditions more than atmospheric changes.

Using mean July temperatures (21 degrees C) at Miskolc (Northeast Hungary) as a datum, the deviation of mean July temperatures from levels somewhat lower than today to as much as 2 degrees C higher than today during the Classical Early Bronze Age is reconstructed on the basis of the South Polish tufa evidence, with mean July temperatures as high as 4 degrees greater than today possible for much of the Late (Urnfield) Bronze Age. On this basis, annual precipitation as modified by local soil conditions can be predicted to vary from age to age. Note that a wide range is employed at Bore 1, reflecting its uncertain age.

<u>Bore 1</u> (pre-Bronze Age?): (ca.) 700 to 800 mm (a <u>higher</u> value is suggested by the *Betula* response at 30.3%)

<u>Hatvan</u> (Early Bronze Age): (ca.) 700 mm

<u>Hatvan-Otomani</u> (Classical Early Bronze Age): (ca.) 600 mm (moderate temperature stress might be expressed by the *Pinus* response at 23.8%)

<u>Bore 4</u> (Late Bronze Age): (ca.) 600 mm (high temperature stress might be expressed by the *Pinus* response at 3.5%)

3 Cf. Bartlein et al. 1986, Pazdur et al. 1988 and Rudolf 1981

Other implications of the Včelínce evidence

An open landscape about Včelínce has important implications respecting the potential of a pastoral adaptation. Extensive finds of equids in Early Bronze Age settlements of the Carpathian Basin, with harness equipment and chariot representations can be seen as reflecting the effectiveness of the horse as a mode of transport in such an environment. As to the extent of arable agriculture, an increase is noted during the course of the Early and the (beginning of the) Late Bronze Age, a pattern not out of keeping with the general trajectory of settlement evidence to be reviewed in Chapter 10.[4] It should finally noted that alluvial pollen evidence from eastern Hungary also indicate a significant human impact on at least localised environments by Bronze Age times.[5]

Mýtna Nová Ves

Further investigations bring us to the Middle Nitra Valley of West Slovakia, a region of intensive Early and Late Bronze Age settlement (Fig. 57, cf. Figs. 105-107). The Early Bronze Age cemetery at Mýtna Nová Ves (156 m a.m.s.l.) overlooking the floodplain was excavated by J. Batorá (at the invitation of the farmer Mr. Gerhát) in the 1980's and 1990's.

Pollen samples were first taken from a grave of the Early Bronze Age Nitra Culture (2300 to 2100 cal. BC), from a bronze spiral tube ("Noppenring") whose "copper-salt" matrix had preserved pollen from that period (Fig. 58). The sample was taken from the cupric-oxide-enriched soil embedded in the centre of the Noppenring, from which an index spectrum could be established for the relative dating of pollen spectra from the adjacent alluvial sequence. Trial borings were then made into alluvium below the first terrace on which the cemetery site lies, 1 km east of the present-day river channel. These revealed a sequence of well sorted silts some 2.9 m deep. Below a 50 cm plough-soil, the sequence was relatively uniform, consisting of pure, reduced silts. Samples were taken at intervals of 290, 270, 250, 235 (with traces of oxidation), 220 and 200 cm for pollen analysis.

Contemporary to the Hatvan period at Včelínce (ca. 2300 to 2100 cal. BC), the initial pollen sample from Mýtna Nová Ves (grave) reveals a more aforested vegetation (cf. Figs. 56 and 58).

4 Furmánek 1977a, 1977b

4 Willis et al. 1998

Rather than an wooded steppe, an open woodland with wet pasture occurs in the Early Bronze Age Middle Nitra Valley. Alluvial woodland is substantially represented by *Alnus* (33.7%), as is a secondary woodland component of *Betula* (7.2%) and *Corylus* (8.4%). The primary woodland is dominated by the thermophilous *Tilia* (3.6%) over *Quercus* (3.6%) in view of the poorer pollen productivity of the former. A mesic pasture is reflected in *Gramineae* (16.9%), *Trifolium* (2.4%), *Asteraceae* and *Cirsium*. Expanding culture steppic taxa include *Artemisia* (4.8%), *Chenopodiaceae* (3.6%) and *Onobrychis*, although these combined comprise less than 10%. Cultivation is also evident in the form of fallow (*Echium vulgare*), arable weeds (*Galium* and *Scleranthus*) and cereals (*Hordeum* and *Triticum* combined at 2.4%). With mean July temperatures of (ca.) 21 degrees C after the ^{18}O data, the response of the culture-steppe community is suggestive of precipitation levels of (ca.) 700 to 800 mm *per annum*.[6]

Alluviation in the adjacent flood plain would appear to have taken place subsequent to colonisation by Nitra Culture farmers. Although these alluvial pollen spectra are conditioned by a different taphonomy, they seem quite comparable to the Noppenring grave spectrum; however, the ratio of primary to secondary woodland is swayed in favour of the latter in the case of the grave spectrum, because of enhanced on-site human influence on local vegetation.

Key "type-fossils" in relatively dating this alluvium include *Juglans* (at 250 cm), which first appears in East-Central Europe (ca.) 2000 uncal. BC.[7] A later development of the culture-steppe (cf. 220-200 cm) correlates with similar spectra elsewhere in the Carpathian Basin (ca.) 1000 uncal. BC.[8] Probably, earlier finds of very large (>70 μ) grains of the *Triticum*-type (at 270-250 cm only) are derived not from emmer wheat (whose pollen grains are much smaller after type-slide material), but rather from *T. aestivum* (whose pollen grains are almost always larger than 60 μ). Given that bread wheat was first grown on a large scale during the time of the Early Bronze Age Mad'arovce Culture, the alluvial spectra at 270 and 250 cm might date approximately to this period.[9] In view of these relative correlations, a constant rate of deposition beginning at 290 cm after the early Nitra Culture (or ca. 2200 to 2100 cal. BC) would signify a rate of sedimentation whereby one cm of alluvium reflects the passage of (ca.) 15 years. From this estimate, very approximate date ranges might be placed on subsequent alluviation at the eastern margin of the

5 Cf. Bartlein et al. 1986, Pazdur et al. 1988, with base-line mean July temperatures interpolated between Budapest and Brno (21 degrees C) after Rudolf 1981.

6 Huntley and Birks 1983

7 Ibid.

8 Hajnalová 1993

Nitra River flood plain, although these must at present remain tentative. Estimates of palaeo-precipitation for these same time intervals are also given.

290 cm (ca. 2500 to 1900 cal. BC): an alder-willow alluvial woodland comprises the most-important pollen component in this spectrum (at 24.8% of A.L.P., minus *Pinus* and semi-aquatics). A primary oak-elm woodland (19.4%) is admixed with quantities of beech and horn beam, although the response of secondary woodland pollen response is weaker (6.2%). As land is cleared, the culture-steppe (20.0%) surpasses pasture (15.5%). The cultural steppe as such includes *Centaurea scabiosa* and *Compositae lig.*, taxa suggestive of somewhat drier soil conditions or increased soil temperatures in the region.[10] Also suggestive of a human inducement of these soil conditions are weeds cultivation (including *Polygonum aviculare*) and relatively high primary cultivation values (2.3%). With inferred mean July temperatures of up to 22 degrees C after South Polish isotopic evidence, annual effective precipitation levels (modulated by local soil conditions) of (ca.) 600 mm can be reconstructed.

270 cm (ca. 2250 to 1650 cal. BC): alluvial woodland has contracted to 20.6%, as primary (15.8%) and secondary woodland (6.2%) also register declines. The mixed-oak woodland now includes both *Quercus* (7.6%) and *Fagus* (3.0%), while *Tilia* (3.1%) replaces *Ulmus* as the primary thermophilous arboreal taxon. The culture-steppe continues to expand (25.0%), as does pasture to a lesser degree (18.2%), which now contains considerable quantities of *Compositae lig.*, with small quantities of umbellifers ringing the forest edge. *Polygonum aviculare* is an important syn-anthropic element in the (spring) fields where *Triticum* and *Hordeum* wax to 3.0%. After mean July temperatures of up to 23 degrees C after ^{18}O data and other proxy data, annual effective precipitation levels of (ca.) 600 mm *per annum* can be reconstructed.

250 cm (ca. 2000 to 1400 cal. BC): alluvial woodland levels are maintained at 19.4% while primary woodland recedes to 10.6%. The latter is comprised of *Quercus*, *Tilia*, *Juglans* and *Carpinus* with traces of *Fagus*. A surge culture-steppe pollen (to 32.3%) led by *Artemisia* and *Compositae lig.* is suggestive of effective rates of precipitation over 700 mm *per annum*, under conditions of moderately high mean July temperatures (ca. 22 degrees C) after earlier Bronze Age tufa data. As cultigens decline slightly (to 2.3%), a new array of weeds appear, including *Galium*, *Plantago media*, *Plantago major* and *Centaurea cyanus*. The last taxon might reflect the winter cultivation of *Hordeum*.

235 cm: degraded pollen and sedimentary oxidation in this layer suggests that water tables are

9 Cf. Bartlein et al. 1986

unusually low during this period.

220 cm (ca. 1500 to 800 cal. BC): profound deforestation has occurred in this spectrum, with a decline of alluvial woodland to 10.7%, and that of primary woodland (*Tilia* and *Quercus*) to 3.9%. Land-use is not intensive (with fallows of 1.0% and no primary cultivation), but an expansion of both pasture (to 24.3%) and culture-steppe (to 35.9%) is none-the-less registered since the 250 cm spectrum. After inferred high mean July temperatures reconstructed from (Late Bronze Age) South Polish ^{18}O data (25 degrees C), maximum effective precipitation levels of (ca.) 600 mm *per annum* are reconstructed.

200 cm (ca. 1250 to 550 cal. BC): after a marginal regeneration of alluvial (13.8%) and continued reduction of primary woodland (3.4%), wet pasture declines to 12.6% as the culture-steppe expands to 48.3%. On this basis, it is suggested that effective precipitation has fallen to 500-600 mm *per annum*, or mean July temperatures exceed 23 degrees C.[11] Weeds of cultivation rise during this period, as reflected in *Caryophyllaceae*, *Polygonum aviculare* and relatively large quantities (1.1%) of *Centaurea cyanus*, an indicator of winter cultivation? Cereals also attain their absolute maximum (3.4%) in this upper spectrum.

The association of cultivation with deforestation and steppification should also not be lost. It would appear that the first two vectors might lead to the latter effect through the alteration of moisture-balance in the soil with the removal of the tree canopy and evaporative exposure through cultivation. Thus the Early Bronze Age transform from brown to black earth grave fills at the site of Jelšovce (8 km south of Mýtna Nová Ves) might be seen as a result of steppification *via* extensive land-use during the period between the Nitra and Mad'arovce Cultures. A potential link between Mad'arovce farming intensity and steppe-formation is reinforced by avifaunal finds of *Otis tarda* at Nitriansky Hrádok.[12] The rate of sedimentation estimated in the alluvial sequence at Mýtna Nová Ves may also be understood in terms of deforestation, in view of the higher rate of erosion (x10) known from steppic environments *vis a vis* those of forest.[13] Unfortunately, poor dating controls of the alluvial sequence preclude its further analytical use in the concluding chapter.

10 Bartlein et al. 1986.

11 Peške 1981

12 Selby (1985) quotes figures produced by the U.S.D.A. for the continental U.S.A. in which grassland can be expected to release 85 tonnes of sediment per square kilometre *per annum*, cf. 8.5 tonnes/km2 *per annum* for forest and 1700 tonnes/km2 *per annum* for crop land.

Sites of the Early Iron Age Horákov Culture in South Moravia

Represented in South Moravia by a grave of the Early Horákov Culture (Hallstatt C or 8/700 cal. BC) at Vojkovice (197 m a.m.s.l.) on the Svratka and a settlement of the Late Horákov Culture (Hallstatt D or 6/500 cal. BC) at Pohořelice (179 m a.m.s.l.) on the Jihlava, Early Iron Age finds derive from somewhat contrasting local environments. Vojkovice lies at the variegated upland margin of the Pannonian biotic province, while Pohořelice lies in a plain near the confluence of the Svratka River with the Jihlava and Dyje (cf. Figs. 59 and 61).

The pollen sample from Vojkovice was taken from under a bronze ring-mail belt found by A. Strof in 1994, from a chamber grave of a young lady (20-25 years) of the Horákov Culture (Hallstatt C), with an array of pottery and animal offerings (Fig. 60). This belt is much like a contemporary find from Brno-Židenice. A <u>woolen</u> textile (preserved by copper salts) forms a backing, thus the embedded pollen grains retrieved might derive from the coats of local sheep.

Vojkovice itself lies on a high terrace overlooking the River Svratka and an intermediate Yazoo-type stream 14 metres below. Only 250 m to the south lies a contemporary settlement of the Horákov culture, while only 350 m to the north comes similar occupation evidence. The bronze ring-mail belt was retrieved by Strof as a block and taken to the unit at Mendlovo Náměstí in Brno, where pollen sampling was performed. Pollen was preserved by virtue of the proximity of copper-salts (toxic to microbes) in the woolen backing (which is also partly preserved after 2800 years), not unlike the grave situation at Mýtna Nová Ves.

The vegetation picture presented from the Early Horákov textile is one of relatively intensive cultivation (combined *Cerealia* and *Triticum* at <u>6.2%</u> of T.L.P.) amid pasture (36.6%) above an alluvial woodland (23.8%, primarily *Abies* and *Picea*) with only small quantities (3.1%) of hard-woods, comprised of *Fagus*, *Carpinus* and *Fraxinus*, as well as quantities (28.6%) of *Pinus* (Fig. 63). The high values of *Abies* and *Picea* are suggestive of local presence, perhaps in the <u>sheltered</u> "Dlouhé příčky" lowlands by the Yazoo-type stream. An isolated find of *Nymphaea* in the grave is also notable given the distance of the deposit from the river in a situation where such pollen cannot travel, nor where sheep are likely graze.

Could this (pond) water lily pollen derive from an anthological tribute to the dead? Such a tribute would fit neatly into a symbolic syntactical context of the Central European Iron Age "horse goddess" Epona, both as bearer of the dead on wagons (across a body of water) and as the goddess of water *per se* (part of her older fertility aspect).[14] In the archaeological context, a widespread symbolic attribution of harness and yoke equipment and bronze mirrors (reflective water) in Hallstatt (Bylany and Horákov) chamber and contemporary Vekerzug Culture pit and tumulus graves is suggestive of identical themes in the regional mortuary cult (cf. Figs. 125-6).

The twin samples from the site of Pohořelice derive from a single settlement feature (Feature 125) of Late Horákov date, a sunken rectangular pit of a kind which might have served an auxiliary function (Fig. 62). A destruction layer of ash (Layer 6) was discerned from near the bottom of the feature, with pollen samples taken from two grey layers of silt and clay above and below the destruction layer. Rapid in-filling of the feature, suggested by distinctively inter-digitated horizons of fill above, as well as capillary action from below has led to the near-perfect preservation of pollen in the lower parts of this feature (cf. Fig. 63).

The lower (pre-destruction) layer presents a picture not unlike that at Vojkovice, with relatively small quantities of culture-steppe elements (5.5% of T.L.P.) in a large expanse of pasture (56.4%) near an alluvial woodland (21.8%). Elements of a secondary (*Betula-Corylus*) woodland appear (at 10.9%) along with small primary stands (3.8%). The alluvial woodland is comprised largely of *Alnus*, probably growing in the low-lying area of "Nová louká" near the Jihlava. Unlike Vojkovice, cultivation indicators are largely lacking, as are arable weeds. The site then suffers a (limited?) conflagration during the Hallstatt D1-2 period, broadly coeval with the "Vekerzug horizon" (see below).

The upper (post-destruction) layer contains somewhat greater levels of primary cultivation of *Cerealia*, *Triticum* and *Hordeum* (1.5% combined), accompanied by arable weeds (1.3%) comprised of *Scleranthus*, *Polygonum persecaria*, *Polygonum aviculare* and *Agropyron*. Presumably, this spectrum reflects conditions after the foundation of agrarian settlement. This cultivation is associated with the felling of alluvial woodland, which declines to only 3.6%, and of primary woodland to only 0.5%. Pasture is extensive, containing primarily *Gramineae* (42.1%) and very minor elements (comprising 0.1 to 0.5% each) of shade- and moisture-loving herbs: *Melampyrum*, *Solanum nigrum*, *Stachys sylvatica*, *Scabiosa*, *Valeriana* and *Filipendula*. Emphatically, a culture-steppe comprised of *Centaurea nigra*, *Centaurea scabiosa*, *Calluna vulgaris*, *Artemisia*, *Chenopodiaceae*, *Compositae lig.* and *Onobrychis* expands to 39.8%.

Recalling Opravil's palaeo-temperature estimates derived from an analyses of wood-charcoal

13 Linkages with prior Bronze Age cult are suggested the application of bird protomes as wagon bearers in bronze and fired-clay representational art of that epoch in Central and Southeastern Europe. Here one might suggest a logical association between the use of avians as weather vanes and an analogous association between water and precipitation which in the case of the Epona funerary cult would focus on the transportive evocational aspect of the former concept.

assemblages from later Horákov features at Bezkov, mean July temperatures of 20-21 degrees C might be reconstructed during this period in South Moravia. Because of wide standard deviation values experienced radio-metrically in this period, it is considered unwise to attempt to associate South Polish tufa fractionation data with this horizon.[15] On this temperature-comparative basis, a quite dramatic decrease in effective precipitation might be reconstructed for later Horákov cultural times, with annual rainfall rates of only (ca.) 450 mm. Pollen counts in the order of 800 grains were made in order to "verify" this singular pollen response on a firmer statistical basis. This reconstruction implies then that growing season rainfall, a key parameter for grassland productivity, would have fallen below a critical 450 mm threshold in the drier interior of the Carpathian Basin which forms the core settlement area of the pastoralist Vekerzug Culture, below which its live above-ground bio-mass of steppe must contract in direct linear relationship to lower effective precipitation.[16]

Archaeologically, this horizon is also coeval with the (votive?) deposit of full-bronze "water-bucket" hoards at Náklo and Býčí Skála in Moravia. Notably, the latter mortuary cave also contains two sacrificial horses in addition to an unusual human osteologic assemblage (see Chapter 11, cf. also Note 13 of this chapter). This is also the period of Bukowski's so-called "Scythian invasion (a.k.a. 'Vekerzug') horizon" in South Poland (see Chapter11 for a discussion of the Vekerzug Culture). In Moravia, this invasion horizon is reflected in finds of trilobate arrows (a Vekerzug type) in destruction layers of hill-forts such as Zelená Hora, Rmíz and other "refugia" of Hallstatt D date in the Drahanské Vrchovina.[17] Further primary pollen data are lacking in Pannonia for a further eight centuries. The former derive from four sites of Marcomannic Wars in South Moravia and Southwest Slovakia.

Sites of the Marcomannic Wars (AD 166 to 180) in South Moravia and Southwest Slovakia

Five ditch-fill profiles from four Roman marching camps of the Marcomannic War have been analysed by the author. From the Dyje flood plain of South Moravia come two sites of the X and XIII Legion at Mušov-Burgstall (a permanent base) and nearby "V Pískách" (a minor camp, cf. Fig. 64). From further east, on the Danubian frontier of Southwest Slovakia come two sites

14 Cf. Opravil 1965, Rudolf 1981

15 Cf. Sims and Singh 1979

16 Cf. Bukowski 1982, Staňa n.d.

of the XI Legion at Můžla Jurský Chlm and Radvaň nad Dunajom, relatively minor camps near a primary Roman cavalry base at Iža (cf. Figs. 69 and 74).

Mušov-Burgstall and "V Pískách"

Mušov-Burgstall (220 m a.m.s.l.) commands a height overlooking the tri-fluvial confluence of the Dyje, Svratka and Jihlava amidst a concentration of Roman marching camps. The establishment date of the Roman camp at Burgstall is still in question, although the majority of finds date from the early and middle stages of the Marcomannic Wars, with numismatic evidence from the destruction fills of the fortification ditches suggestive of an abandonment after AD 171-173 (Fig. 65). Pollen samples taken from the secondary fills at 125 and 105 cm from the Roman fortification ditch certainly date from the time of the Marcomannic Wars, perhaps reflecting floral historical events over nine or more years (the duration of the war up to the Aurelian truce, see Chapter 12), although the basal sample from 145 cm might date to a period earlier than the war (often, Romans would prepare military installations years in advance in anticipated operations). A reconstruction of environmental history at these levels follows which reflect events on a time-scale of only 10^1 years (cf. Fig. 66):

<u>145 cm</u>: *Pinus* comprises 52.5% of T.L.P., indicative of its regional presence under a favourable climate. Also at this time, an alluvial woodland of *Abies* and *Picea* with traces of *Alnus* and *Salix* lies in the Dyje flood plain, with only traces of woodland of *Quercus* and *Corylus* (1.3% respectively). With the Roman occupation of this area formerly intensively settled by "Germanic tribes", cultivation indicators are <u>lacking</u>, while an open landscape is represented by pasture (21.1%) and culture-steppe (10.3%).

<u>125 cm</u>: *Pinus* representation falls to 29.5%, indicative of either local felling or conditions of moderate temperature and/or moisture stress. Alluvial woodland has fallen to 6.2%, while traces (2.1%) of primary woodland remain. Primary cultivation remains absent, while the open landscape is comprised of culture-steppe (17.8%) and pasture (44.5%), percentage changes modulated by the pine decline. After reconstructed mean July temperatures of the Early Roman Optimum (20-21 degrees C), the culture-steppe pollen response indicates local effective precipitation levels of 500-600 mm *per annum* (see below).

<u>105 cm</u>: *Pinus* declines to only 11.8%, with the slight <u>expansion</u> of the alluvial and primary

woodland and agricultural wasteland indicators (*Marrubium vulgaris* at 0.5%). The most-important change at this time, just before the deposition of the Roman destruction-abandonment layer, is the expansion of the culture-steppe (to 50.2%) over pasture (at 25.6%), modulated to a lesser extent by the *Pinus* decline (which might also reflect moisture stress). After temperatures of the Early Roman Optimum, the culture-steppe component is indicative of effective rainfall levels of 4-500 mm *per annum*. But given the degree of local Roman activity in the form of the enduring presence of (ca.) 10,000 troops for nine or more years, it is entirely likely that this relative pollen response reflects an anthropogenically-modified local and regional (plant-soil micro-climate) ecology, in the felling of woodland and the compaction of soils on exposed and abandoned native fields, which are only now coming back into use with the Aurelian truce.

Affirming aspects of the findings at Mušov-Burgstall are two spectra from primary (170 cm) and secondary (105 cm) fills of a v-shaped ditch from the Roman marching camp of the X or XIII Legion at "V Pískách" (180 m a.m.s.l.), intersecting a "Germanic" settlement on the southern bank of the River Dyje, one kilometre south of Mušov-Burgstall (cf. Figs. 64 and 67). A local alluvial woodland pollen component is lacking here (Fig. 68). Presumably, these riparian woods are felled by the Romans, because no traces of actual cultivation are evident. Conversely, a culture-steppe of nitro-phylic *Artemisia* and halophytic *Compositae lig.* predominates (at 65-68.8% of T.L.P.) on the inundation area of the Dyje. The designated halophytic pollen response is so strong as to raise suspicions of its local (gravity component) over-representation, although the local situation would also be most favourable for salt-tolerant floral development with soil exposure and compaction (i.e., non-tillage). The initial Roman occupation level (170 cm) still reflects relict traces of pastoral flora in *Plantago lanceolata* (3.9%), although these disappear in the subsequent fill-level (105 cm) with a continued Roman presence in the region.

Můžla Jurský Chlm and Radvaň nad Dunajom

Two camps of the XI Legion at Můžla Jurský Chlm (124 m a.m.s.l.) and Radvaň nad Dunajom (113 m a.m.s.l.) lie near the *limes* of the Danubian frontier (Fig. 69). Můžla Jurský Chlm itself lies on a terrace at a remove of several hundred metres from the Danube, while

Radvaň nad Dunajom lies closer to the inundation area of the Danube in Southwest Slovakia.

Two sections were examined from Můžla Jurský Chlm, one (Section 2) from the eastern fortification ditch and one (Section 3) from the western fortification ditch of the Roman camp (Figs. 70 and 72). Section 2 reveals a complex stratigraphy reflecting an initial establishment, followed by abandonment which is succeeded by a secondary ditch cutting. The initial vegetation picture presented by Section 2 is that of a steppe (83.3% of T.L.P.) comprised primarily of *Artemisia* and *Compositae lig.*, without primary cultivation (Fig. 71). Relatively little pasture (13.8%.) or alluvial woodland (0.7%) is evident. After the departure of the Roman cohorts, primary cultivation (*Cerealia* at 1.2%) appears, along with a waxing of "mesic" pasture (to 27.7%), while alluvial woodland also recovers (to 3.0%). With the second Roman occupation, traces of cultivation again disappear, and in the middle fills of this second occupation, the culture-steppe also returns to <u>initial</u> Roman occupation response levels. The <u>post</u>-Roman upper fills reflect then a recovery of alluvial woodland and mesic pasture.

Section 3 to the west of Section 2 reflects a parallel sequence, although here, the second ditch-cutting has removed parts of the primary fills of the first ditch. As such, arable fields (*Cerealia* at 1.1%) are probably concurrent with the second consecutive sample in Section 2, (i.e.) after the first Roman occupation, but before the reestablishment of the marching camp (Fig. 73). Similarly, the lower fills of the second cutting resemble the lower and middle fills of Section 2's second cut, with an rise of the culture-steppe component (to 72.9%). The upper fills of Section 3 are also much like those at Section 2, with a culture-steppe contributing only 47.5%. The coeval situation of the Roman camp at Radvaň nad Dunajom is now considered.

Near a Roman military cemetery dating to the early part of the Marcomannic Wars (established after AD 166 according to coin evidence, see map in Fig. 74), the examined section of a v-shaped fortification ditch at Radvaň nad Dunajom contains primary and secondary fills of a Roman occupation, as well as a feature profile of Early Medieval (Avar) date (Fig. 75). An open environment is reflected throughout the sequence, although unlike Můžla Jurský Chlm, the initial pollen spectrum from Radvaň nad Dunajom reflects moister (initial) conditions (Fig. 76). Initially, pasture (77.8%) predominates, with a relatively high proportion of alluvial woodland (8.6%) as seen in *Salix* and *Alnus*. <u>Secondary</u> traces of cultivation appear here, with finds of *Marrubium vulgaris* (0.5%) and *Plantago media* (1.1%) representing fallow or wastes, and *Polygonum aviculare* (0.5%) representing arable weeds. In the lowest secondary fills, the steppe's halophytes expand as the alluvial woodland contracts, reflecting a destructive local

Roman influence on the local vegetation ecology. The pollen spectrum is similar in Avar times, although limited arable indicators (*Secale cerealia* and *Centaurea cyanus*, cf. Vranský potok Zones 18-20) are now evident, reflecting cultivation by native Slavonic communities. This population is politically dominated by Asiatic Avar pastoralists at this time; compare then the Slovak "kôň" (konje, a non-indo-European root in Old Slavonic) and the Mongol (cf. Avar) "quong" terms for "horse".

A full emergence of the modern Pannonian steppe by Early Roman times is supported in the totality of local evidence from Mušov-Burgstall, "V Pískách", Můžla Jurský Chlm and Radvaň nad Dunajom. The ecology of "Germanic" (or Eggers B2/C1) agrarian settlement is difficult to reconstruct, because of the destructive influence of Roman incursions on the agricultural cycle. Even at "V Pískách", (which directly intersects a prior "Germanic" settlement), no traces of primary cultivation appear. Where these traces are found at Můžla Jurský Chlm, they occur between successive Roman occupations. Likewise at Radvaň nad Dunajom, only the lowest fills contain (secondary) traces of Germanic agriculture, which subsequently disappear. An increase in halophytic vegetation as reflected in the *Compositae lig.* maxima of the Roman occupational phases at these four sites must reflect then an increase in salt precipitation on the Danubian floodplain, due either to poor moisture penetration from above (on abandoned fields) or to a rise in the floodplain water table following upon the felling of alluvial woodland biomes which also supply these marching camps with construction materials.

After this geo-botanical evidence, Dio (in Books LXXI-III) is furthermore affirmed in his assertion that Roman commanders actively sought to disrupt native agriculture as part of a campaign of logistic attrition on the northern barbarians of the Marcomannic Wars, leading to local native population migration as well as lower levels of regional-indigenous population density.

Review towards general conclusions

In terms of quantity and chronological control or scope, the primary Pannonian data base is more limited than the Hercynian one in its ability to address the question of human impact on the environment in later prehistory. Site-by-site limits may be surmised as follows:

1. Včelínce in East Slovakia: periodic coverage of the Bronze Age is significant, however the significance of its spectra may be largely local. The reflection of steppe development is thus influenced by both human activity and climate. Although beyond the eastern limit of the primary study area, the site of Včelínce provides an interesting ecologic contrast to less continental (Bronze Age) conditions reconstructed in the Northwestern Carpathian Basin.

2. Mýtna Nová Ves in West Slovakia: limitations of dating are severe here, although a general Bronze Age coverage is inferable in the alluvial sequence after relative archaeologic and pollen time-markers. Areal catchment of pollen spectra may be quite great, in the order of 10^{2-3} km^2.

3. Vojkovice and Pohořelice in South Moravia: these limited data-set sites provide some local or micro-regional coverage of the Early Iron Age period in the northwestern margin of the Carpathian Basin, however certain inter-site differences in pollen taphonomy may reduce the inter-site comparability of these pollen spectra.

4. Mušov-Burgstall and "V Pískách" in South Moravia and Můžla Jurský Chlm and Radvaň nad Dunajom in West Slovakia: these locally significant sites provide insights into Roman impact on the environment, but little indication of the undisturbed quality of native cultivation.

The history of agriculture and steppe evolution described in these site sequences can now be compared to the development of later prehistoric agricultural settlement in Pannonia, which will be described in Chapters 9-12. Ultimately, this primary data base allied with secondary pollen findings from well-dated later Holocene sediments at Mistřín in South Moravia (cf. Chapter 5) will be employed in a negation of the Behaviouralist hypothesis in Pannonia, after an alignment of higher primary cultivation values expressed at these geo-botanical sites with higher general population densities to be reconstructed from archaeological data (cf. Chapter 13). The further importance of steppe development in promoting the emergence of pastoralist groups in Pannonia will also be reviewed in the concluding chapter (14), together with a consideration of the relative effects of periodic steppic aridity on outward movements of pastoralist groups such as those reflected in the emergence of the Late Hallstatt Vekerzug Culture.

After further environmental data, the Climatic hypothesis will also be considered with a view towards emergent inter-zonal differences in the history of primary cultivation levels in the post-Neolithic, post-Climatic Optimum period of Pannonia and Hercynia.

8. First farming in Central Europe

Beginning with the Linear Pottery Culture period (57/500-4400 cal. BC), the first farming regimes of the Primary Neolithic in Central Europe are reviewed in this chapter, in which the subsistence practices which constitute "optimal farming" are also defined.

The first farmers in Central Europe originate either from native hunter-gatherer or Carpathian Basin faming groups of Körös Culture derivation, although a general preponderance of material evidence along dual lines would suggest a significant demographic contribution from the latter settlement zone. Principally, a discontinuity of most material culture elements is evident with the introduction of food production, elements including lithic technology, with notable site-specific exceptions (Hurbanovo West Slovakia and Brunn in Lower Austria) on the northwestern periphery of the Carpathian basin. Secondly, Epi-Mesolithic settlement coeval with the Primary Neolithic can be traced in the upland and wetland interstices of prime farming areas in Central Europe into the Early Eneolithic (i.e., Consequent Neolithic), where hunter-gatherer lithic material at non-farming settlement sites is bracketed by independent dating methods (e.g. radio-metric dating at Pobiel 10 and ceramic dating at Grodźiszcze 7 in Silesia).[1]

These dual lines of evidence argue for the agency of migration rather than in-situ adaptation in explaining the change from food collection to food production in Central Europe, *circa* 5500 cal. BC. Environmental evidence is also supportive of some direct derivation rather than adaptation of southeastern agriculture in Central Europe in that temperature conditions promoting a Southeast European agro-climate in Central Europe are encountered during the Climatic Optimum. Affirming the significance of climatic factors in the spread of farming, the limits of Linear Pottery settlement also follow the outer limit of a (COHMAP) reconstructed +2-4 degrees C contour for relative summer temperature differentials (ca.) 4800 cal. BC, wherein the Zips Basin in the Central Tatras is modeled to have even higher (adiabatically modulated) temperature differentials of 4+ degrees C.[2] This highland basin also contains exceptional evidence for Middle Linear Pottery Culture settlement at far removes from primary agricultural zones in the loessic lowlands to which first farming is almost exclusively restricted.

1 Bagniewski 1992a

2 Huntley and Prentice 1988, Pavúk 1982

First farming regime in Central Europe

The core characteristics of Near Eastern agriculture appear in Central Europe during the Middle Holocene Climatic Optimum, a transformation now dated to as early as 57/5500 cal. BC after data from Brunn am Gebirge in Lower Austria. Two main elements of this new economy include the harvesting of emmer wheat and the raising of livestock for meat and secondary products.[3] By secondary products it is meant the production of milk, cheese and raw materials for textiles from livestock, primarily from cattle and sheep in the context of later prehistoric Central Europe. As will be discussed by section in this and following chapters, it is now believed that significant milk and cheese production occurred from the time of first farming onwards. Direct evidence for wool production comes later, primarily in the Bronze Age, whence the first definitive evidence for horse domestication also occurs. The establishment date for the use of the economically important traction ard is still open to debate, although it should be noted that limitations of the Primary Neolithic evidence make it unlikely that direct traces of traction ard use will be preserved.

The known technology of first farming economy then is simple, this being based on stone implements for the clearance of forest and the harvest of wheat, while its energetic basis is probably exclusively human, for livestock are not yet demonstrably (soil micro-morphological evidence notwithstanding) exploited for purposes of transport or traction.[4] The seasonal labour requirements in such an agrarian regime would be quite significant during the sowing and harvesting period, a factor which might encourage the formation of large co-residential groups during Primary Neolithic times.

Assuming that the soil is tilled by hand at this early date, the clearance of land would involve only the cutting of timbers, without the requirement of removing their extensive underground root system. The labour requirement for such forest clearance is still significant, however, as filmed experiments with Neolithic stone axes in the Draved Wood of Denmark by the Copenhagen Museum are suggestive of an optimal forest clearance rate of one hectare per 285 man-hours expended.[5] More realistically, film records of timber-cutting by modern "stone age" people such as the Dani of New Guinea suggest

3 Bogucki 1984, 1988

4 Piggott 1983, Sherratt 1986. For contra arguments regarding the early use of animal traction, see Chapman 1982.

5 Jørgensen 1985. The above experiments were also conducted on beech, a tree more difficult to cleave than the oaks and lime trees which dominated the forests of Neolithic Central Europe.

that these experimental rates should be adjusted downwards, an inference justified by observations by Steensberg in Papua New Guinea of stone axe use by a Mr. Dagore, who felled a 20 cm diameter doli tree within seven minutes by means of strong downward oblique blows to the trunk at lower chest level.[6] The tendency of the Draved woodsmen to apply rapid if less forceful sideward blows is less effective. In view of the above, the efficiency of prehistoric woodsman would be at least double that of the Danish team (or ca. 140-150 person-hours expended per hectare of woodland clearance).

Once land had been cleared, the next task for the Primary Neolithic farmer would be the planting of crops and the care of livestock, where before the establishment of open pastures, woodland grazing and leaf-foddering for over-wintering was probably practised. The over-wintering of livestock within the long houses of the Neolithic farmer has never been demonstrated, to which end, phosphate analyses conducted at Olszanica in Little Poland reveal no marked concentrations.[7] Until extensive clearance for grazing is achieved, herds would be limited by the labour required for gaining winter fodder, as well as the trophic limitations of woodland grazing.

In this respect, the natural feeding habits of cattle, sheep and pig vary according to their specific habitat. Cattle are better-adapted to a mixed environment of light woodland and pasture, and can both browse on low branches of trees and shrubs and graze on grasses and herbs. Sheep are restricted to open habitats, although here they are better adapted to drier pastures than are cattle. Swine in contrast are best adapted to woodland environments. Ecologic considerations aside, cattle provide the best returns in terms of time expended in animal husbandry.

Both sheep and cattle could be exploited for their milk products, although ancient herd sizes are perhaps too small to produce sex and age ratios expected for the optimisation of production of secondary products.[8] Given the probability that local Early Neolithic clearings are limited to areas some tens of hectares in extent, the population of gazing

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6 Steensberg 1991

7 Cf. Troels-Smith 1960 and Bogucki 1984, 1988, Milisauskas 1986

8 Barker 1985, cf. Bogucki 1984, 1988. Peške (1994) notes that the age and sex profiles of most Early Neolithic assemblages fail to provide evidence for the culling of male calves as per an optimising milk-producing economy. The proportion of the death assemblage under four to five years as measured through the eruption of the third lower molar is consistently under 35% during the primary Neolithic period, while during the subsequent Eneolithic period the proportion is consistently over 60%.

herds is also probably limited to under 50 head of cattle.[9] Assuming then that secondary products were exploited, Russell calculates a return of some 400 to 600 Kcalories per hour of labour in the care of 50 head of cattle. Given then a theoretical maximum herd size of 100 head, cattle produce a higher rate of return of some 800 to 1500 Kcalories per hour of labour expended. Under similar conditions, 100 sheep produce a return of some 250 to 400 Kcalories, or less than a cattle herd half its size.[10]

Arable farming in the Neolithic is based primarily on emmer wheat, with einkorn, barley and (sometimes) millet providing a small admixture to these finds.[11] The returns from arable agriculture are greater than those obtainable from pastoral, despite a lack of metal tools and animal traction. For example, the calculated return rate for the production of emmer wheat reaches 2,300 Kcalories per hour of labour expended on optimal land, while the returns for barley would rate marginally higher than wheat.

To put harvesting labour into perspective with that required for woodland clearance, experiments suggest an average labour requirement of 185 person hours per hectare of wheat reaped using reconstructed sickles with flint blade inserts.[12] Because flint sickle blades function most effectively on dense stands of wheat, it has been assumed that such fields were densely planted.[13] Also, if Linear Pottery sites in the Middle Rhineland might serve as a guide, these fields are also quite small (as inferred from the shade-tolerant weeds at Langweiler 3 and 6).[14] On this initial basis, the first farmers would select arable over pastoral production unless environmental conditions threaten periodic crop-failure. However, because the pastoral economy provides nutrients which the arable economy cannot, the former always plays an important (if secondary) role in subsistence.

9 Cf. Soudský and Pavlů 1972. Assuming that a large settlement such such as Bylany 1 contains thirty hectares under cultivation with thirty hectares of field under fallow, only twenty-five head of cattle could be maintained on the stubble alone, with a considerably larger herd being supportable from woodland grazing. after agronomic data of 18th Century pastoral farming in East Prussia. These data indicate that a single head can be grazed for the half-year on 1.16 hectares of fallow land. Summer half-year woodland grazing in East Prussia supports more livestock, with each 0.28 hectares supporting a single ox (cf. Russell 1988).

10 These calculations are taken from Russell's (1988) study of the dynamics of early food production in the Near East and North Africa.

11 Finds of emmer out-number finds of einkorn by a ratio of 2:1 in Early Linear Pottery Culture finds (no. = ca. 270) in Poland (Kulczycka-Leciejeczowa 1988). In Slovakia, Hajnalová (1990, 1993) records a ratio of 3:2. From Bohemia, the finds-ratio would appear to mirror the Polish Neolithic pattern (Wasylikowa et al. 1991).

12 Korobkova (1981) used flint sickles of a type reconstructed from Tripolje cultural finds..

13 Beranová 1991

14 Knörzer 1973

The initial spread of farming in Central Europe

The settlement and subsistence system of the first farmers in Central Europe is the end-product of an adaptation of a Balkan farming regime at its northern periphery to an environment of aforestation. The demographic mechanism behind this establishment is as yet indeterminate, although there is evidence from Hurbanovo and Brunn on the outer northwestern fringe of Pannonia for a significant hunter gatherer contribution to material culture on early farming sites. Three to four centuries after the foundation of agriculture in the Balkans, the farmers of the Linear Pottery Culture in the Western Carpathian Basin practice an agricultural regime quite distinct from the Körös Culture to the east.[15] In the Linear Pottery Culture, farming is practiced on well-drained soils atop loessic substrates, rather than alluvial soils preferred in the dry farming regimes of the Balkans. Cattle, better adapted to woodlands than sheep, now dominate among the domesticates, while fishing diminishes greatly in importance.[16] It is this regime which is adopted over a distance of 1-2,000 kms (into Central and Western Europe) within *circa* 500 years.

The first Neolithic sub-phase is called the "Krumlov Phase" (before 5200 cal. BC) in the Czech and Slovak Republics and parts of Germany. Its pottery is characterised by a high degree of plastic ornamentation (e.g. the barbotine motif) like that in East Hungarian Körös assemblages. Representative Krumlov assemblages from West Slovakia and Moravia are known from Hurbanovo (West Slovakia), Žopy by Holešov (East Moravia) and Velatice near Brno.[17] Notably, all major settlement areas in West Slovakia are occupied during this earliest phase of the Linear Pottery Culture, although only at Hurbanovo do traces of Late Mesolithic settlement also appear (on adjacent sand dunes). A similar situation where Mesolithic-style lithic artifacts occur in some profusion is encountered at Brunn in Lower Austria. Very early radio-metric assays which calibrate to 5500 cal. BC or before are derived from this considerable settlement of 34 long-houses, although the ceramic assemblage itself is almost entirely comprised of Körös-like material, a situation somewhat atypical of most other Earliest Neolithic sites which contain

15 Kosse 1977, cf. Whittle et. al. 2001 and Mateiciucová 2001 for a discussion of the Brunn evidence.

16 Kosse 1977. Dohle (1993) also cites Upper Danubian sites where pig bone is common, this phenomenon being attributable to particularly dense forests extant there. Sherratt (1983) notes then the situation of sites of the Körös Culture, which are strung-out along major rivers as if to maximise fishing resource exploitation.

17 Pavúk 1980, Tichý 1960

a wider array of material from different phases of the Linear Pottery Culture. With respect to the degree of inferred hunter-gatherer inter-action or derivation of the farming population, Brunn may also be a site atypical of the wider Linear Pottery complex.[18]

The appearance of Early Neolithic material Moravia is also widespread, where 51% of all Linear Pottery sites produce Krumlov Phase ceramics, a pottery style which is also found at settlements across Bohemia and in Eastern Bavaria. In Poland, finds of the Earliest Linear Pottery Culture are much more restricted, primarily to Upper Silesia and the upland cave of Ojców in Little Poland, a site which also produces early traces of hexaploid spelt wheat in small quantities. Traces of millet and rye are also known from various Polish sites, but in quantities non-indicative of intensive cultivation (these finds are rather more probably reflective of an odd inclusion of weeds of cultivation).

The distribution of finds of early farming settlement emphasises a landscape use almost exclusively limited to low-lying areas along a presumable colonisation zone up the tributaries of the Danube, a zone which extends through the whole lowland of Bohemia and Moravia. In contrast, upland Southwest Bohemia produces extensive evidence for Late Mesolithic settlement with finds of lithic implements such as pressure-flaked mini-discoid scrapers and (steeply beveled) micro-blade trapezes, suggestive of a regional persistence of hunter-gatherers.[19] Conversely, Linear Pottery lithic assemblages most often lack pressure-flaking, while implements such as (percussion-flaked) end-scrapers, truncated-blades (without beveling or notching) and macro-blades are common. Ground and polished stone tools for timber-cutting and wood-working are also characteristic, although these implements also appear in areas without other Primary Neolithic settlement evidence.[20] The latter finds may represent the use of axes by native hunter-gatherer communities.

Identifying farmers vs. food collectors

The distinction between late hunter-gatherer and early agricultural peoples in the Central Europe is a question of difference in not only material culture, but also of subsistence

18 Mateiciucová 2001

19 J. Militký of the South Bohemian Museum pers. comm. and obs. of collections, Autumn 1993.

20 Ten such find spots are recorded in South Bohemia (J. Militký pers. comm., 1993), where the only early farming settlement in the region is that of an isolated long house at Žitumice in the basin of České Budějovice (Pavlů 1972).

modes and techno-complex definition, whereby the differentiation of lithic technological traditions is particularly important.[21] Some archaeologists have suggested that agricultural transformations involved in the Early Linear Pottery period might have been effected by native hunter-gatherers rather than agricultural immigrants. Under this hypothesis, a lack of continuity in material traits such as domestic structures, ceramics and polished stone tools might be seen as necessary in view of the degree-of-difference in the life-ways of food collectors *vs.* food producers. However, this techno-complex-based argument is empirically contradicted by differences in Neolithic lithic technology, which includes many properties not determined strictly by transforms of subsistence modes. In the Linear Pottery Culture, this technology is ultimately derived from farmer-fishermen of the Körös Culture in the Carpathian Basin rather than the Janisławice-related techno-complexes of Central Europe. Sites where there is a significant admixture of Mesolithic-related lithic artifacts, such as Brunn am Gebirge, are rather exceptional, and might also serve to emphasise rather than detract from an appreciation of a wider material culture pattern of relative non-interaction between food producers and gatherers.

That the settlement by native food gatherers continues in areas marginal to agriculture has also been proposed, although few sites of the former have been adequately dated towards substantiating this proposal. However, finds from the hunter-gatherer site of Pobiel 10 in Silesia within the Primary Neolithic settlement zone provide an exception, where the third (and last) horizon is bracketed by radio-carbon dates from peats.[22] The lower layer of this thus assays at 4230 uncal. BC, coeval with the Middle Linear Pottery Culture, while the upper layer dates to before 2870 uncal. BC or the earlier Eneolithic. Between these dated organic layers lay an assemblage of beveled trapezoidal microliths and other lithic artifacts and properties diagnostic of the Late Mesolithic Janisławice. Suggestively, the Pobiel 10 fauna also consist almost entirely of wild species, including beaver, fox, wild horse, pig and red deer, although an ovi-caprid bone reflects limited contacts with regional farmers.

Although very few sites of the Late Mesolithic techno-complex in the Czech Republic have undergone radio-carbon-dating, it would appear that elements of these assemblages occur on sites of both the Early and Late Primary Neolithic, although in general, these

21 Cf. Nandris 1972 and Tringham 1968, 1972

22 Bagniewski 1992

contacts appear very weak. From the Linear Pottery settlement at Mohelnice (North Moravia), Epi-Mesolithic lithic artifacts derive from a single pit (51), reflecting limited hunter-gatherer contacts. Similarly, at the coeval cemetery of Vedrovice (South Moravia) of 106 graves, but a single grave (57) contains a full assemblage of dorsally-beveled trapezoidal microliths of a Late Mesolithic type.[23]

Comparatively then, the 7.5 hectare excavation of the Linear Pottery site at Bylany 1 in East Bohemia produces almost no evidence for hunter-gatherer contacts, while the 2.5 hectare area investigated at the contemporary site at Březno produces no evidence at all. Six centuries later, however, certain Late Neolithic sites of the Pannonian Early Lengyel Culture produce more extensive finds of Epi-Mesolithic micro-lithic technology. For example, an inhumation "impaled" by a flint trapeze from the Early Lengyel enclosure at Friebritz in Lower Austria provides clear evidence for the projectile use of this artifact type.[24] Epi-Mesolithic lithic types are furthermore not rare at the Early Lengyel circular enclosure at Těšetice-Kyjovice in South Moravia, where ten trapezes are known in a lithic assemblage of 220 artifacts deriving from eight features.[25] Additional links with hunter-gatherer micro-lithic technology are detectable in the Early Lengyel burin-and-drill assemblage at Těšetice, although E. Kazdová dismisses these (numerous) lithic finds as merely reflecting the "reuse" of much older hunter-gatherer artifacts.

Developments in Late Neolithic agriculture and the definition of optimal farming

The agricultural regime of the Neolithic period is one of enduring continuity. Emmer wheat continues to be the main grain crop into the period of the Late Neolithic Lengyel Culture, with slight admixtures of einkorn wheat and barley.[26] Emmer wheat has a demonstrated preference for semi-arid climate, and it is well suited to dry-farming in the present day steppe and forest-steppe zones.[27] However, the intolerance of emmer for cooler and moister temperate climates would have made its cultivation less reliable during

23 Tichý 1961, Podborský 1993

24 Neugebauer 1986

25 Kazdová 1984

26 Hajnalová 1986, 1989, 1993, Wasylikowa et al. 1991. At sites of the Rössen Culture in the Lower Rhine Valley, barley supersedes emmer wheat as the primary crop (Bakels 1989, Dohrn-Ihmig 1983).

27 Carlton 1901, Zohary and Hopf 1988

climatic minima. Other edible crops such as lentil and pea only rarely appear at this time. Seemingly, benefits to the soil derived through the fixation of nitrogen provided through the bacteria on the roots of these leguminous plants were yet to be appreciated.[28]

Innovations towards the raising of textile crops are evidenced through the appearance of both flax macro-fossils and ceramic impressions hemp-seed during the later Neolithic period.[29] Further archaeological proofs of the use of these textile crops comes from the impressions on Late Neolithic pottery vessels from Iža in West Slovakia and preserved remains of vegetable fibres (*via* cupric oxides) from Late Neolithic copper artifacts at Třebestovice in Central Bohemia.

A final question remains as to the first implementation of the primitive plough or "traction ard". The traction ard, when harnessed to a team of oxen, greatly improves dry farming, increasing its caloric return rate from 1900/2300 Kcalories per hour up to 2500/3200 Kcalories per hour on optimal land.[30] This increased efficiency of almost 50% would have encouraged the adoption of the ard, although limits in its use lie in the availability of cleared land.[31] The process of forest clearance would have been a slow and continuous one, when this takes into account the removal of the "root mat". After ethnography, one might presume that labour inputs for forest clearance would have to be multiplied by a factor of <u>five</u> in order to remove this obstacle to ploughing, for an estimated labour requirement of <u>700-750 man-hours per hectare</u> cleared.[32] Because the clearance of land can be expected to be a male activity on the basis of the ethnographic record, male roles in the farming regime might also have become more important.[33] Furthermore, the decreased importance of manual labour in soil preparation would reduce the importance of female reproduction in the provisioning of an agricultural work-force.[34] This reduced economic status of the female might then account for a decline in the quantity if not quality of female figurine manufacture, although mortuary evidence for a

28 Wasylikowa et al. 1991

29 Tempír 1963

30 Russell 1988

31 Cf. Sherratt 1986

32 Boserup 1970

33 Murdock and Provost 1973

34 Cf. Vincent 1979

reduced female-status is inadequate due to a scarcity of burial remains.

Harvesting of the crop would still have required large labour inputs; however, introducing a seasonal imbalance in the agricultural labour regime. Smaller groups might be required for ground-preparation, but the end of the agricultural season would still require high labour in-puts for the harvest, unless the crop assemblage is diversified in order distribute this agricultural labour. The relative importance of grain over pastoral production can be assumed then under optimal conditions, while the introduction of the traction ard might systemically encourage an absolute (but not necessarily relative) expansion of the pastoral sector of the agricultural regime.

The adaptive implications of Table 8.1 (below) are clear: somatic-adaptive behaviours which would be selected for include the raising of cattle rather than sheep and the raising of wheat crops over stock in general (unless browsing, grazing or growing conditions become sub-optimal), while the introduction of the traction ard might promote larger stockherds in order to provide drought animals for agriculture. The net result would be a more extensive agriculture as wider tracts of land can be brought into cultivation.

Table 8.1. Comparison of energy inputs into different modes of agriculture

Mode of agriculture	Energetic returns	Forest clearance requirements
Arable w/ traction ard	2500 to 3200 Kcals./ man-hour	700 to 750 man-hours/ hectare
Arable w/ hand-tillage	1900 to 2300 Kcals./ man-hour	140 to 150 man-hours/ hectare
Cattle w/ milk products (x 100)	800 to 1500 Kcals./ man-hour	n/a
Cattle w/ milk products (x 50)	400 to 600 Kcals./ man-hour	n/a
Sheep w/ milk products (x 100)	250 to 400 Kcals./ man-hour	n/a
Sheep w/ milk products (x 50)	200 to 250 Kcals./ man-hour	n/a

Early evidence for the introduction of the traction ard in Central Europe comes from Sarnowo in Greater Poland, where Early Funnel Beaker Culture long barrows preserve traces of ard-marks. Charcoal from these traces is assayed to (ca.) 3600 uncal. BC, a date which corresponds to the Lengyel III period.[35] Pollen analyses from fills of these marks also suggest that they date to a concurrent forest clearance episode, so it is likely

35 Dąbrowski 1971

that the dated charcoal might derive from old wood (i.e., an assay ca. 200 years older than the dated context). Comparatively then, a Lengyel IV terra-cotta at Hradisko by Kroměříž in Central Moravia appears to represent a teamed pair of oxen (for traction?).[36] Although it is not possible to date precisely the introduction or invention of the traction ard in Central Europe, an Early Eneolithic minimum limiting date can be established. Once animal traction is brought to bear, the caloric returns in arable agriculture would compare still-more favourably to a pastoral economy with secondary products, where return rates of arable are greater than pastoral by a factor of 570%, with cattle herds of 50 or less, while arable still out-produces pastoral production by a factor of 250% when cattle herds of (ca.) 100 head are maintained.

Proto-Eneolithic developments

Six centuries after the establishment of agriculture in Central Europe (39/3800 uncal. BC), the cultural sequence diverges into two separate orbits of development. The temperate Hercynian zone gives rise to the Late Neolithic Stichbandkeramik, while a "continental" Pannonian zone witnesses the emergence of the broadly contemporary Lengyel (I-III) cultural sequence, (ca.) 39/3800-35/3400 uncal. BC. The early part of the latter sequence (Lengyel I-II) is particularly notable with respect to the appearance of macro-village agglomerations of 500 or more inhabitants. These macro-sites then devolve into much smaller settlements during later phases (III-IV) of the Lengyel Culture (terminating at ca. 33/3200 uncal. BC with the emergence of the Jordanov Culture). This Late Neolithic period of hamlet-based settlement archaeology is then contemporary with the earliest conclusive evidence for the evolution of ard-based arable agriculture.

During the subsequent Eneolithic epoch (33/3200-19/1800 uncal. BC), more complex cultural geographic entities emerge. Hercynian and Pannonian cultural orbits may now clearly be discerned, although mutually overlapping, transgressive (coeval) cultures characterise the macro-geographic pattern. Material culture in individual assemblages also becomes more polythetical, thus "cultural affiliation" as contrived by typological systems can be problematical. Importantly, cycles of settlement agglomeration and dispersal occur on shorter (2-300 year) time scales, in contrast to the 10^3 year time-scale decline of agrarian settlement observable during the later Neolithic period in Hercynia.

36 Pers. obs. at the National Museum in Prague

9. Eneolithic agricultural settlement of Bohemia, Moravia and Slovakia

The farming settlement of the Eneolithic (or Copper Age) period in Central Europe is reviewed in this chapter (see Figs. 77-78). In cultural terms, early, middle and late periods are recognised, although in absolute chronologic terms, the early (Jordanov-Funnel Beaker-Fürchenstich) period comprises half the Eneolithic time-span. In natural terms, agro-climates of the early and late periods might be described as minimal or highly variable over secular time-scales. Settlement sites of the Early and Late Eneolithic are also small, diffuse or short-lived, occupations suggestive of a degree of systemic micro- (10^{0-1} km scale) mobility when compared to the continuity of Primary Neolithic settlement systems. Significantly, the material culture of both the Early and Late Eneolithic is largely boreal in origin. Conversely, the somewhat shorter middle period of larger, more concentrated and sometimes fortified settlement witnesses the northward diffusion of Pannonian cultural elements into Hercynia, in the Late Channeled Ware (Kamýk sub-phase), Jevišovice (Vučedol elements) and Řivnáč (terminal Baden) Cultures. This middle, maximal settlement phase corresponds to the Eneolithic agro-climatic maximum after proxy data sources.

The spatial patterning of cultural distribution is somewhat regionalised during the Early Eneolithic. In contrast to the Primary Neolithic pattern, cultural zones largely corresponding to modern bio-geographic ones have emerged (e.g. Funnel Beaker in Hercynia, Fürchenstich and Early Channeled Ware in Pannonia). Certain Eneolithic cultures also develop a geographic distribution pattern after potential infiltrations into sparsely occupied areas after transformations of the natural limits on agriculture. For example, Cham Culture settlement emerges in the (previously sparsely populated) uplands of Southwest Bohemia due to the enhanced agrarian potential of this rather marginal region, after an extension of the growing season of the Middle Eneolithic maximum (see Chapter 4).

Directional diffusion is also discernible when material is divided into (less-than one century) sub-phases, for example in the three Find Groups (F.G. I-III) of the Late Eneolithic Corded Ware Culture. Finds of the pan-European horizon (F.G. I) are rare, although Central European horizon (F.G. II) sites are concentrated in Northwest Bohemia, avoiding zones densely settled by farmers of the prior Řivnáč and Cham Cultures in Central and Southwest Bohemia. In contrast, Local Group horizon (F.G. III) finds are more evenly distributed through Bohemia, although the non-occupation of upland Southwest Bohemia continues, due to denuded agro-climate conditions. A complementary concentration of Terminal Eneolithic Bell Beaker sites can also be observed in the low-lying basin of Litoměřice and the Český Brod bottom lands, the warmest and driest regions of Bohemia. A coincident minimal agro-climate is suggestive of a meso- (10^{1-2} km scale) mobility on the part of Bell Beaker farmers, who infiltrate into lowland areas of higher arable potential in the absence of steep population gradients. A correlation of Bell Beaker settlement with such czernozem soils is not particular to this culture, and similar associations may be cited with respect to multiple archaeological cultures as these also tend to be areas of densest settlement.[1] It has been proposed by Wilhemy that such settlement foci have in fact promoted a partially anthropogenic, "degraded" czernozem development.

Relative to the Primary Neolithic, the agriculture of the Eneolithic may be said to contain a more diversified pastoral component, with the demonstrable use of cattle for traction and transport with ards and wagons (although a Neolithic use of such technology remains a possibility). Osteologic evidence for a more specialised (sheep and cattle) milking economy (after culling data derived from teeth) and a higher proportion of wild (hunted) taxa are two further patterns of importance to note with respect to Early Eneolithic faunal assemblages (see Note 2).[2] The latter tendency, in addition to an increased micro-regional settlement of inter-fluves, marks a biome expansion of the Primary Neolithic subsistence system as knowledge of resources outside principal arable zones is incorporated into the cognitive-adaptive maps of the Eneolithic farmer.

Given a previously noted contraction of temperate Neolithic settlement in its later stages and evidence for continued hunter-gather occupation of intervening upland and wetland regions, might this Early Eneolithic subsistence and settlement trajectory not reflect a mixing of (relict) hunter-gatherer and agricultural populations in Central Europe? After proxy data, a reduced agro-climatic *K* capacity, farming population decline and subsequent re-orientation of mating networks of food producers towards more proximate hunter-gatherers (thus reducing the mean variance of mating distance) might be invoked as an ancillary (and partly-somatic) population biological hypothesis prior to a detailed consideration of Eneolithic settlement history.

The Early Eneolithic sequence and its polythetical inter-cultural relationships

The Eneolithic agrarian settlement of Bohemia, Moravia and Slovakia presents a complex

1 Shennan 1978, but cf. Smrž 1994, Wilhemy 1950, Rulf 1983

2 See Peške 1994 for a list of analysed Neolithic and Eneolithic faunal assemblages.

cultural historical pattern. Radio-carbon dates for this era span (ca.) 3200 until 19/1800 uncal. BC, or more than 1,500 years in calendar terms. During this period, these territories witness the emergence of more than a dozen cultures, many of which are both contemporaneous and over-lapping in their macro-geographical distribution.

The period 3200 to 26/500 uncal. BC (41/4000 to 35/3400 cal. BC) sees the appearance of cultures in Bohemia and Moravia whose pristine origins lie in the temperate zone of Northern Europe, namely the Funnel Beaker and Michelsberg Cultures. In contrast, the Pannonian regions of Eastern Moravia and Western Slovakia continue to express Late Neolithic material cultural traditions indigenous to the Carpathian Basin, traditions which are derived from Lengyel IV cultural substrates, as defined by quite exhaustive ceramic and settlement structural studies.[3]

The Funnel Beaker Culture in Bohemia and Moravia is divided into two main phases, namely an early "Baalberg" and a late "Salzmünde". The Baalberg Phase is notable for the creation of plain pottery with smooth profiles and characteristic funnel-shaped necks found amongst beaker and amphora types. The pottery of this "boreal" culture also forms the principal basis of the material culture in the lowlands of Bohemia between (ca.) 3200 and 2900 uncal. BC, along with admixtures of "western" Michelsberg elements at sites in the valley of the Ohře in Northwest Bohemia.[4] These Early Eneolithic pottery types are also sparsely ornamented on their surfaces, so that cultural attribution is problematic in the absence of reconstructable diagnostic vessel shapes (cf. Fig. 79). The site of Březno provides one such example, where plain pottery identified as Baalberg has been reassigned to the Michelsberg tradition.[5]

Still-more complex is the material relationship between the Baalberg and ("epi-Neolithic") Jordanov Groups, in which house-building and burial traditions are shared. Plotiště in the district of Hradec Králové in East Bohemia serves as one example, where a cremation grave (in the Jordanov rite) lay adjacent to an isolated trapezoidal long house of a foundation-trench type encountered at Jordanov sites elsewhere, although the grave itself contains Early Baalberg pottery.[6] An analogous closed find of artifact types occurs at Mužký in North Bohemia, where

3 Particularly the Jordanov and Ludanice groups as per Pavúk and Šiška (1981). The territory of Eastern Moravia, lacking Funnel Beaker sites, is most probably occupied by communities of the Late Lengyel (IV) Culture during the Baalberg Phase (cf. Houštová 1960 and Pavúk and Bátora 1995). Cf. esp. Kamienska and Kozlowski 1990.

4 Lünning 1967

5 Pleslová-Štichová 1981a, E. Neustupný pers. comm., 1995

6 Vokolek 1993. The multi-family long house at Plotiště extends some 26 m in length, while its breadth extends some 7 m on its shorter and 9.4 m on its wider side. Similar, if isolated long houses of Jordanov date have also been reported from Klučov and Třebestovice in Central Bohemia.

a mixed ceramic hoard contains both Early Baalberg and Jordanov pottery (cf. Fig. 79).[7] It would appear then that the bearers these cultural entities are at least partially contemporary and locally inter-acting over inter-penetrating distances in the order of 10^{1-2} km.

The Early Eneolithic settlement in the highland zone can also be understood as inter-active culture contact with "relict" hunter-gatherer groups inhabiting areas unsuitable for agriculture, a scenario which has trans-Central European analogues at Pölling and Grodżiszcze 7 in the highland zones of Upper Bavaria and Polish Silesia respectively These latter sites produce the first evidence in Central Europe for presence of material culture from farming cultures in the highland zone outside of the Zips Basin in the Tatras.[8] "Epi-Mesolithic" lithic artifacts from Eneolithic sites in Central Europe are also known from farming sites dating to as late as 3500-3000 uncal. BC), for example in the early occupation at Łacko 6 in Greater Poland. Evidence from hunter-gatherer sites such as Pobiel 10 in Silesia (see above chapter, see also Note 8) strongly suggest that such occupations, indistinguishable from earlier Mesolithic-type sites, continue into the early period of the Funnel Beaker Culture. Subsequently, a complete population syncretism between hunters and farmers may be inferred.[9]

During this same period, Pannonian cultural influences occur in the "Fürchenstich" attribute discernible at 22 localities in Moravia. This ceramic decor is characterised by deep strokes which push clay upwards in the manner of plough furrows which are then arranged on pottery in linear patterns and encrusted with shell. In West Slovakia, pure assemblages are encountered, for example at Bajč and Čataj, sites where Fürchenstich appears as a transitional stage between the Late Neolithic and Early Channeled Ware.[10] Little is known of its settlements, although it seems likely that Fürchenstich sites contain only small populations.

7 Pleslová-Štichová 1981a

8 The Early Eneolithic settlement at Pölling lies at a high altitude (590 mamsl), although it seems unlikely that grain was actually grown in-situ. The site of Pölling extends some 2.4 hectares according to surface finds, where Müller-Karpe (1961) has also detected post-built structures and a cultural layer of Eneolithic date some 20 to 30 cm thick in one trial trench. Site debris includes a singular *metate* fragment, which relates to arable agriculture, as well as a much more prodigious animal bone assemblage. The latter assemblage also contains a large proportion (over 80% of the M.N.I.'s) of wild species including red deer, bear and boar. Further highland finds of the Early Funnel Beaker period include those from the Polish Südeten Mountains, where there are juxtaposed Late Mesolithic elements at the site of Grodżiszcze 7. Here at an altitude exceeding 1,000 mamsl, excavations produced sherds of the Funnel Beaker Culture in the upper-most part of a late hunter-gatherer occupation layer. *En toto*, some 1,047 lithics were recovered throughout the latter, a techno-complex unchanged with the tefnal (Early Funnel Beaker) occupation phase (Bronowicki 1993).

9 Significant techno-complex transformations also occur in the Late Mesolithic, when inter-regional techno-complex differences are greatly reduced in Central Europe, as assemblages come to be universally dominated by trapezoidal microlith forms.

10 Točík 1961a, J. Pavúk pers. comm., 1993

The settlement archaeology of the Baalberg Phase is poorly developed in both Moravia and Bohemia. From the earlier Baalberg Phase (Ib) in Moravia, only small lowland settlements are known (cf. Figs. 77-8), for example, Velatice near Brno which produces two circular pits (ca. 1 m across) containing typical settlement debris. Generally, lowland sites are of low surficial visibility and tend to be found accidentally during the course of systematic excavations, although more visible hill-top occupations are also known from the later Baalberg period.

Funnel Beaker hill-top settlements are best attested in Moravia, where 17 sites of Late Baalberg and Salzmünde date occur. Most impressive of these sites is Rmíz by Laškov in Central Moravia, where four ditch-and-bank fortifications protect the gentle northern approach to the promontory settlement (Fig. 80).[11] Although the total area of the enclosure exceeds 17 hectares at Rmíz, the inner-most settlement area occupies little more than 6 hectares.[12]

In South Moravia, the later part of the Baalberg Phase witnesses the first intensive occupation of small (under 4 hectare) hill-top sites with stratified cultural deposits. Best known of these stratified (tell-like) hill-top sites is that at Jevišovice in Southwest Moravia.[13] At 383 mamsl, Jevišovice lies on a height some 50 m above the adjacent Jevišovická drainage. Four stratigraphic units are identified by Palliardi atop the hill, with the lowest and thinnest layer (D) producing Late Neolithic pottery, overlain by a (ca.) 40 cm thick settlement layer (C2) of the Baalberg Phase. In addition to later Baalberg pottery, one can distinguish a rich assemblage of tools. Tree-felling for example appears to have been an important activity, after the 32 nearly complete celts and 8 shaft-hole axes in the collection. Hunting also seems to have been significant, for bored boar's tusk and wild animal teeth occur prodigiously.[14]

In Bohemia, similarly thick (anthropogenic) deposits are known only from the hill-top at Slány, where the Baalberg layer has an average thickness of 30 cm.[15] Amongst low-lying "flat" sites, early settlement finds include two long houses of post construction discovered at Březno

11 Rakovský 1990

12 The ditch along the less-steep northern approach at Rmíz is preserved to a depth of one metre. A single line of defense lies along the steep (60 m) western, southern and eastern approaches (Šmid n.d., cf. Fig. 80).

13 Šmid 1992, n.d.

14 Medunová-Benešová 1981a. The exploitation of extra-local hornstone is interesting in that this might reflect a lack of knowledge of local "Jevišovice plasma" lithic sources which are used in later periods (cf. Přichystal 1991).

15 Moucha's excavations at Slány remain unpublished, although Müller-Karpe (1974) refers to an earlier and later Baalberg phase at this North-Central Bohemian site. Each Baalberg phase is represented by a layer ca. 30 cm thick.

in Northwest Bohemia.[16] The dimensions of these structures recall those of Jordanov sites; (e.g.) one house (88) is almost 24 m in length and 7 m in breadth. Associated ceramics suggest an Early Baalberg date, as do finds from a second long house (96) and two settlement pits. Michelsberg elements are also apparent in these finds, confirming both their date as well as suggesting extensive down-the-line cultural contacts.[17] Although it is difficult to estimate the full extent of the Eneolithic settlement, the residential area enclosed by both long houses amounts to almost 280 m^2. After Narrol, this would suggest a total co-residential population of about 25-30 individuals, should both domiciles be occupied contemporaneously.[18]

Material culture of the Salzmünde Phase of the Funnel Beaker Culture and the Channeled Ware Culture

The (later) Early Eneolithic cultural sequence witnesses the development of a major cultural division between the Hercynian and Pannonian culture zones, with the further evolution of the Funnel Beaker Culture in Bohemia and the emergence of the Channeled Ware Culture in Moravia and Slovakia.[19] Pottery of the Salzmünde Phase of Bohemia witness an enrichment of Funnel Beaker surface treatment, composed primarily of vertical zones of incised lineal decoration. Ceramic types also develop high-necked and carinated forms which replace the smooth profiles characteristic of Baalberg vessels.

The defining attribute of the Channeled Ware is a diagonal channeled decoration which appears on a minority of vessels, usually cups or bowls. In West Moravia, the first Channeled Ware is comprised of small vessels (primarily cups) in closed grave contexts.[20] These artifacts, belonging to Phase C of the (A-E) Baden sequence, attest to the Pannonian orientation of later Funnel Beaker communities of Moravia prior to the appearance of coherent Channeled Ware

16 Pleinerová 1981

17 E. Neustupný pers. comm., 1995

18 Naroll 1962. These two domiciles are widely separated within the extensive excavated area (2.5 hectares) at Březno.

19 Pleslová-Štichová (1989) cites assays from Bohemia and Moravia demonstrating the contemporaneity of the Salzmünde Phase and the Channeled Ware Culture. From Salzmünde contexts at Makotřasy, a date of 2765 (+/- 60) uncal. BC compares well with an assay of 2730 (+/- 30) uncal. BC from Prague-Baba and five dates from Channeled Ware contexts at Hlinsko which average ca. 2725 uncal. BC.

20 E.g. in Tumulus 12, Grave 2 and Tumulus 14 at Ohorzim (Houštová 1960).

assemblages in Phase D of this sequence.[21] Notably, Channeled Ware also directly overlies later Baalberg layers at Jevišovice (Layer C1),[22] while east of the Morava River, evidence for a longer and more continuous development of the Early Channeled Ware from Fürchenstich is demonstrated at Bajč in Southwestern Slovakia.[23] In this eastern zone, Fürchenstich comprises a more substantial cultural assemblage; and it is furthermore probable that the Channeled Ware also begins earlier here (Phase C is represented by cohesive [i.e. "non-mixed"] assemblages). Conversely, it would appear that the Channeled Ware sequence in East Bohemia represents a more truncated cultural phenomenon, making its first cohesive appearance after the Kamýk Sub-phase (Early Phase D), when many attributes of the Funnel Beaker Culture persist as "mixed-types".[24] Channeled Ware here appears to be based on a "native" (Salzmünde) substrate which produces "mixed-types", in contrast to the situation in Moravia, where individual "pure-Channeled Ware types" appear as admixtures in closed "mixed-assemblages". The specific social meaning of mixed assemblages is difficult to infer, but it is not unreasonable to assume these assemblages reflect some kind of fortuitously definable social interaction ("fortuitous" in the sense that these interactions occur on the usage boundaries of archaeological cultures).

Settlement populations of the Salzmünde Phase of the Funnel Beaker Culture

From the Salzmünde Phase in Bohemia there are only three excavated settlements of significance; these sites include the unenclosed lowland (300 mamsl) site at Lysolaje by Prague, and the hill-forts at Mužký (North Bohemia) and Prague-Baba (Fig. 81).[25] Firstly, Lysolaje has produced at least 18 features of the Funnel Beaker Culture within an area of 0.435 hectares, with surface finds strewn over a 3.5 hectare area. Excavated in sub-optimal conditions during the last world war, it must be expected that only deeper settlement features were recovered. Multiplying these Early Salzmünde features by the inverse of the excavated ratio, it follows that this occupation might have contained about 1-200 settlement pits of sub-circular plan in total. Assuming then that an average of two pits would correspond to an (undetected) above-ground

21 Neustupný 1973

22 Houštová 1960 and Medunová-Benešová 1964

23 Točík 1961a

24 Neustupný 1973

25 Pleslová-Štichová 1981a, 1981b. Like Baba, Mužký produces rather dispersed occupational remains.

house (a ratio inferred after Prague-Baba, see below), *circa* 50-100 houses might have been built at Lysolaje during the active life of the site of about eight generations of the Early Salzmünde Phase. With a range of six to twelve single-family houses being coeval, an approximate population range of 30-60 is reconstructed. Salzmünde find densities are similar on the hill-top site of Mužky, although Prague-Baba, six km south of the settlement at Lysolaje, will serve as a model for an enclosed hill-top settlement of the period. Baba occupies (ca.) 5.5 hectares of a loess promontory south of Šárecky potok, where ceramic finds from the 4,615 m^2 area excavated date primarily to the Early Salzmünde period, associated with an assay of 2730 (+/- 60) uncal. BC from animal bone.[26] From the sparsely represented second phase come younger Salzmünde types, associated with sporadic Channeled Ware. After Havel's assessment, the promontory site is occupied intensively for a period of (ca.) 100+ years.

Important to this discussion are traces of so-called "sunken huts" at Baba. Two sunken huts of a more regular plan also contain typical domestic refuse in their fill, including spindle whorls and spools (in Features 10/77 /78). Both features produce isolated internal post-holes, while the latter feature also contained a pit-hearth; however, two further "huts" of regular plan and modest size (Features 46/77 and 47/77) lack such attributes. Importantly, two surface post-hole patterns also occur in the southwestern part of the site, of which one group forms a rectilinear pattern almost 11 m long, adjacent to a second 3 x 5 m pattern and a more confusing array (Fig. 83). Some 30 m west of these patterns lay five deep storage pits (Fig. 82). From the post-hole clusters, a minimum of five houses within the excavated area should be reckoned with, for a reconstructed on-site sub-surface feature to post-house ratio of 2(-):1. A magnetometer survey also reveals a pattern of occupational density similar to that of the excavated area (cf. Fig. 81), so one might extrapolate finds within the 8.5% of the site excavated by a factor of twelve, for a product of 60 domiciles. Assuming that at least 40 of these huts belong the century-long period of Baba I, an occupational maximum of ten coeval households may be reconstructed. These (ca.) 50 inhabitants also comprise a site population comparable to those reconstructable from Funnel Beaker sites in Poland.[27]

Quite impressive considering the limited extent of settlement finds is the collection of 31

26 Surrounding stony and clayey soils are comparatively less-suitable for agriculture using the primitive traction ard.

27 By way of comparison, a contemporary promontory settlement of Late Funnel Beaker date and similar extent (7 hectares) at Wojnowce in the County Opole in Upper Silesia has been subjected to intensive excavation (Bagniewski 1992b). Within the 277 m^2 area uncovered, a large number of settlement features were discovered. Of these, only three (Features 4, 9 and 25) correspond to Havel's (1986) and Pleslová-Štichová's (1985) conception (probably erroneous) of a "sunken hut". The density of this class of find at Wojnowce is comparable to that at Baba.

ground-stone celts and one half-completed adze from Prague-Baba. Along with similar finds from Moravia, there appears to be an order-of-magnitude increase in the use of such wood-cutting tools since Neolithic times, most-likely towards the cutting of forest in preparation for the more-extensive type of agriculture encouraged by the adoption of the traction-ard.[28]

Settlement populations of the Channeled Ware Culture of Moravia-Bohemia

Coeval with the Salzmünde Phase, Moravia sees the emergence of the Channeled Ware Culture upon a truncated Funnel Beaker sequence. Links with the previous Funnel Beaker Culture are suggested by the appearance of Channeled Ware assemblages on previously occupied sites, for example at Jevišovice and Brno-Líšeň (cf. Fig. 84). The sequence at Jevišovice continues without a break, where a 25 to 30 cm thick culture layer (C1) is laid-down. The Channeled Ware layer (II) at Brno-Líšeň also preserves a post-built house reinforced with wall trenches, clay floor and fire place within a 15 m^2 internal area, corresponding to a home for a nuclear family. Of further interest with respect to the organisation of domestic groups are finds from Hlinsko hill-top (318 mamsl) in East Moravia, including the remains of houses constructed with stakes and wall-grooves enclosing living areas ranging between 24 and 32 m^2 (Fig. 84). These excavations also produce an array of terra-cottas which may reflect cultural and agricultural interests, including a "plank-like" gynomorph and numerous bovine figurines. Generally, cattle represent the central subject of the Channeled Ware terra-cotta art.[29] One from Vysočany is also interesting in that its decoration represents a harness, suggesting that cattle were valued for their provision of animal traction.

Sites of the Bohemian Channeled Ware appear in both low-lying and hill-top situations. Amongst the former, only Prague-Lysolaje has a substantive amount of settlement evidence, consisting of only five features. Given the truncated nature of the Channeled Ware sequence in Bohemia, it seems likely that Lysolaje's occupation lasts for little more than a century (ca. four human generations). Using a 1:1 ratio of regular sunken features per domicile discernible at Moravian Channeled Ware sites (cf. Fig. 84), a population of (ca.) 50 individuals can be

28 Comparing the demographic estimates with total axe/celt finds or their fragments (adjusted for the un-excavated portions of sites and their duration of occupation) at Early Neolithic Březno and Early Eneolithic Baba, a much higher rate of axe-use is evident at the latter site. A ratio of one axe or celt find for every 96 inhabitants per year of occupation can be reckoned with at Březno, while an annual ratio of one axe or celt finds per inhabitant/year is suggested at Baba.

29 Medunová-Benešová 1964, Pavelčík 1983

reckoned with. Considerably larger site populations will emerge in both Moravia and Bohemia in the Middle Eneolithic.

Middle Eneolithic cultural developments in Moravia

The Middle Eneolithic (25/2400-2200 uncal. BC, 3200 to 2750 cal. BC) of Pannonia is represented by two divergent cultural groups of Late Channeled Ware. East of the Morava River lies the zone of the Bošáca Group, known from the systematic excavations at Hlinsko.[30] West of the Morava lies the settlement zone of the contemporary Jevišovice Culture, known primarily from hill-top localities. Pottery decoration diverges markedly from the Channeled Ware pattern during this period, with the Bošáca Group adopting vertical and horizontal linear designs composed of shallow pits upon high-handled bowls and beakers whose forms (but not attributes) follows prior traditions.[31] Conversely, Jevišovice Culture pottery introduces a series of motifs and forms derived from cultural groups to the south, for example an array of externally applied triangular fields in Fürchenstich arrayed in horizontal bands and star patterns, the latter decoration being particularly characteristic of Vučedol low-footed-bowls. Pottery forms of the Jevišovice are also more various; in addition to footed-bowls there are found a series of handle-less beakers and jars, as well as larger egg-shaped amphorae.

Settlement populations of the Middle Eneolithic Jevišovice Culture in South Moravia

Extensive artifact assemblages of the Jevišovice Culture are known from the epynomous site as well as other hill-forts. That this period reflects the apex of Eneolithic settlement intensity is seen in Layer B from Jevišovice, where deposits vary between 30 and 80 cm in thickness. Recalling that the combined Baalberg and Channeled Ware periods reflect a duration twice that of the Jevišovice Culture, the latter midden must reflect an occupation of double the intensity

30 Pavelčík 1964. Sporadic finds of the Bošáca Group are still found as far west as East Bohemia, where a single settlement pit (Feature 182) is known from Plotiště (Vokolek and Zapotocký 1990).

31 Pavelčík 1964, Neustupný 1973

compared to that of earlier Eneolithic.[32] Ground-stone artifacts include 40 celts or adzes and 28 shaft-hole axes, a large sample amounting to 170% of the collection from Layer C1.[33]

The hill-top settlements at Grešlové Mýto and Křepice provide further opportunities to study the structure of Middle Eneolithic settlement in South Moravia.[34] At 401 mamsl, the hill at Grešlové Mýto lies 50 m above the surrounding landscape. A terrace area of (ca.) 3.5 hectares contains extensive settlement traces as detected by a series of six profiles excavated in 1966, although a much larger area was uncovered by Palliardi at the end of the 19th Century. The Middle Eneolithic settlement layer here varies between 20 and 50 cm in thickness and contains a large assemblage of Jevišovice material in a matrix of organic-rich sediment.[35] Significantly, the 1966 investigations also revealed six large culture pits spaced some 8 to 10 m from one-another, most probably representing "minimal household clusters" (cf. Homolka below).[36]

Extrapolating from this observation, one may presume that Jevišovice Culture households are relatively densely spaced on-site, a reasonable assumption given the thick, tell-like deposits which are observable. Assuming then that this observed pattern of household spacing holds constant for the entire site, about 350 "clusters" might span the occupation. Given then the long duration of the Jevišovice Culture, some ten generations of occupation may be assumed, resulting in a quotient of about 35 contemporary minimal domestic clusters of individual nuclear families, for an estimated total of (ca.) 175 inhabitants at Grešlové Mýto.[37]

Importantly, a clue as to the rationale for the defensive situation of many Jevišovice sites comes from Křepice, where <u>limited</u> test trenching produced a concentration of 80 arrow-heads,

32 Neustupný (1973) estimates the duration for the Late Funnel Beaker and Channeled Ware occupation at Jevišovice (Layers C2-C1) at ca. 550 calendar years. This estimate should be regarded as a minimum duration, observing that the Jevišovice Culture itself begins at ca. 2900 cal. BC in absolute terms. Taking into consideration then a dendro-date for the I Horizon of the Corded Ware Culture of 2750-2680 cal. BC (Hardmeyer 1992, Winger 1993) and the appearance of a Type A hammer-ax in Layer B at Jevišovice, a <u>maximum</u> Jevišovice occupational duration of 320 years is reconstructed. The contemporary (cf. <u>Czech</u> Middle Eneolithic) sedimentary situation at the North Balkan Eneolithic tel of Vučedol is analogous, where two successive Vučedol Culture layers attain a thickness of 1.6 m, compared to the 1 m accumulation of settlement debris attained in the significantly longer duration of the Baden Culture (Schmidt 1946).

33 L. Šebela (pers. comm., Spring 1994) also believes that this axe contains some native Moravian attributes in its manufacture.

34 Medunová-Benešová 1964, 1973, 1986 and Strof 1992

35 A small quantity of earlier Channeled Ware also appears in Palliardi's pottery collection, although the chronometric significance of these finds was not realised at the time of his initial (pre-1914) excavations.

36 Cf. Kuna and Turková 1987

37 In the Jevišovice occupation of Brno-Líšeň, one concentration of burnt daub extends 6.5 x 5 m, and is indicative of the presence of a wattle-and-daub house (cf. Fig. 84). Given the discovery of an earlier sleeper-beam hut of Channeled Ware date from the same site, it seems likely then that habitation of nuclear family homes continues from Channeled Ware into Jevišovice times (Medunová-Benešová 1964).

mostly of local hornstone, an indication of a raid in antiquity by local hostile tribals? Notably, limited osteologic evidence from Middle Eneolithic Řivnáč Culture settlements is also suggestive of similar events (cf. Homolka and Vraný below).

Middle Eneolithic cultural developments in Bohemia

The Middle Eneolithic agricultural settlement of Middle and Eastern Bohemia is dominated by the Řivnáč Culture, a late derivative of the Channeled Ware Culture, typified by an elaboration of plastic decoration on both fine and course wares.[38] Such plastic decoration includes bands with incised decoration or warts, as well as stylised bull-horns or "ansae lunatae". Coarse vessels, particularly pots and amphorae, are often also impressed with "Besenstrich" (straw-roughening) decoration. The eastern half of Bohemia is also occupied by yet another culture, that of the Globular Amphorae, whose distribution over-laps somewhat with that of the Řivnáč in Central Bohemia. Near Hradec Králové in East Bohemia, there are also traces of Bošáca and Globular Amphora occupation. To this complex mosaic are added isolated elements of the Jevišovice Culture which appear on sites of the Řivnáč and Cham Cultures (in the West Bohemian uplands of the Plzeň basin region, cf. Fig. 11). The pottery of the Cham Culture has plain surfaces and carinated forms which exhibit links with contemporary cultures in Bavaria.[39]

Settlement populations of the Middle Eneolithic Řivnáč Culture in Central Bohemia

Settlements of the Řivnáč culture are known from both unenclosed lowland and hill-fort locations, although the latter predominate. Thus, these are not quasi-central places.

Serving as an example, the hill-fort site at Homolka is the most thoroughly investigated site of the period, where almost the entire occupation of 0.8 hectares is excavated (Fig. 85). Homolka

38 Cf. Neustupný 1973

39 Excavations by Franc (1906) at the southern edge of the Plzeň basin in the Southwest Bohemian uplands constitute a primary source for our knowledge of the Cham Culture. This culture is typified by a relatively limited array of pot, jar and beaker forms, mostly with gently rounded profiles, sometimes with abrupt carinations. Its decorative properties include a subset of those known from the Řivnáč Culture. Besenstrich occurs on large storage jars, while on smaller vessels, linear bands of incised plastic decoration are applied. This distinctive pottery bears a close resemblance to finds in East Bavaria, the barrier of the Šumava not-withstanding (Müller-Karpe 1974). Two sites investigated by Franc, at Bzí (604 mamsl) and Lopata (440 mamsl) are both hill-top settlements. Notably, the tool-kit of the Cham Culture contains a disproportionate share of celts. The collection from Bzí contains 29 such pieces, as well as two broken fragments of shaft-hole axes. Grinding stones are also encountered at Bzí, including four whole slabs and numerous fragments.

itself lies amongst a cluster of half-a-dozen Řivnáč sites in the Stehelčeves area, where it overlooks the surrounding countryside from a relative height of some 23 metres (at 284 mamsl). Fortification is effected by a ditch-and-palisade system established during the first phase of occupation. This line is extended southwards by 12 metres during the second phase.

The enclosed area is densely settled, with the perimeter wall ringed with 26 small huts (some 16 to 25 m^2 in area). Of these, some 13 are dated on the basis of their ceramic assemblage to the first phase, which is sub-divided into sub-phases Ia and Ib, while a further ten huts are established during the second phase of occupation in the area between the second and original palisade. The failure to rebuild in the northern part of the site suggests that most of this area is still densely-occupied during the second phase of occupation (i.e., some of the central huts are actually occupied for multiple human generations).

A further 39 "presumptive hut units" occur in the central (highest) part of the site, where slope-wash has been more intensive. The super-position of huts is observed in only one case (Huts A and B). Whether or not all huts of the first phase are contemporary remains problematic, but given the duration of the Řivnáč Culture, one might imagine that the super-position of Huts A and B reflects a wider tendency in that *circa* half of the settlement features of the first phase are contemporary. The division of Phase I into two sub-phases hints at the further divisibility of the central settlement area into <u>three</u> distinct phases of occupation. The addition of "new-comers" during the second phase required the extension of living-space down the southern slope (because the central area is still occupied), for a habitational total of 32 single-family huts at the height of occupation (or ca. 160 inhabitants).[40]

The economy of the Eneolithic farmers at Homolka seems inclined towards arable rather than pastoral production, as finds of milling stones are extremely common, with up to seven discovered per hut unit.[41] Of quern stones, 12 complete examples occur in addition to numerous fragments. Stone celts for wood-cutting are also common, with a typical hut unit producing up to four such artifacts. Items of agrarian "cult" include two terra-cotta female figurines, both deposited in Feature 19. These feminine "idols" wear bull-horns, a syncretism perhaps between gynomorphism and an increased importance of the cattle-cult. In this respect, it should be recalled that the ancient Hellenic mother-goddess Hera also bears the totem of a

40 Settlement histories of individual Řivnáč sites vary. For example, the Řivnáč site of Dänemark in East Bohemia is occupied by (minimally) eleven families during its initial pre-fortification phase. After the establishment of a multiple line of ditch-and-palisade defenses, site population appears to have contracted to only four families. Relative effects of <u>erosional</u> vectors have not been systemically considered at these recent excavations.

41 Cf. Prague-Baba where only three ground stone *manos* and *metates* were discovered *en toto*.

feminine horned bovine. Economically, cattle are also most important amongst the domestic animals, accounting for the majority of individual bone fragments and a plurality of the minimum number of individuals. Osteometric analyses also suggest that wild cattle are incorporated into the herd.[42] Fragmentary dog bone occurs at Homolka, although at Vraný, one canine receives a formal burial outside the site limits (cf. Fig. 86).[43]

Recalling the possible bow-and-arrow raid at Křepice, the broadly concurrent occupation at Homolka produces an unusual isolated skull find of an older male under the floor of House I. Contemporary finds from Vraný of cut-and-smashed human bone in settlement features might also be suggestive of some manner of sanguine ritual if not the results of a hostile tribal raid.[44]

Social conditions as inferable from Middle Eneolithic burial practice

Little or marginal degrees of ranking may be inferred from the little known of Middle Eneolithic burial practice. Apart from finds in settlement layers such as those referred to above, there are only isolated examples of "ritual" burials of both males and females. For example, one intramural burial pit from Hlinsko in East Moravia derives from House 15/79, and contains an adult female whose burial goods include a bone needle, a storage vessel and a shaft-hole ax (usually a male burial attribute).[45] Further burials of a special character include inhumations of cattle in large globular pits. One such burial (1159/81) at Svodín in Southwest Slovakia is subsequent to four human inhumations, of which the upper (secondary) three included two infants and an older adult male. On the floor of this pit lay the primary internment of an older female. Assuming that the upper interments are attributable to the primary burial, a burial attribute of the "patriarch" has been assigned to the converse, although similar cattle burials at Dolní Veštonice in South Moravia contain primary male internments. Sporadic mass burials also occur at this time. For example, Nitriansky Hrádok produces a shaft (Feature 107) with twelve inhumations surrounding a hound; a second shaft (Feature 119) contained between 19 and 25 individuals.[46] These latter mortuary features may reflect specific cult practices or events

42 Ambros 1968

43 Knor n.d.

44 Sikmundová and Chochol n.d.

45 Pavelčík 1990b

46 Němecová-Pavúková 1986

of mass mortality, coeval with not uncommon traces of para-mortal violence at Řivnáč fortified sites. Evidence for such mortality events fails to appear in the very much larger funerary assemblages of the Late and Terminal Eneolithic periods.

Late Eneolithic Corded Ware cultural sequence

The Late Eneolithic period (2200 to 19/1800 uncal. BC) in Bohemia is comprised of two successive cultures: the Corded Ware and Bell Beaker. The former mortuary-dominated group is of North-Central European origin. The latter culture is of cosmopolitan composition, although it too is dominated by mortuary finds. The cultural sequence is complex in South Moravia, at the northern edge of the Pannonian biotic province.

The Corded Ware sequence in Bohemia has been divided into three chronological phases: the "Pan-European" (I) the "Central European" (II) and "Local Group" (III) horizons in succession. The Early Corded Ware Culture in Bohemia belongs to part of a wider grouping whose designation as the "Pan-European A-horizon" (dated *via* tree-rings) begins at (ca.) 2750 cal. BC (or ca. 2250-2200 uncal. BC in radio-carbon terms).[47] Assays for the Local Group horizon (III) also consistently register between 1900 and 2050 uncal BC, comparable to the dendro-chronological maximum limiting dates for the end of the Corded Ware at 2450 cal. BC.[48]

The A-horizon (I) of the Corded Ware is composed of a limited set of artifacts associated in closed contexts.[49] The primary aspect of this assemblage are amphorae whose forms are clearly derived from the Globular Amphora Culture.[50] The decoration of these vases is distinct from the stamped-and-corded decoration employed in the latter culture. Instead, incised lineal decoration is used to produce a series of metopes on the upper body of amphorae. Secondary aspects of these assemblages include simple beakers and smoothly profiled ground-stone "A-axes". Finds of the A- (or I) horizon in the territory of Bohemia consist of less than a dozen

47 Buchvaldek 1986a, Hardmeyer 1992, Winger 1993

48 Ibid. Buchvaldek (1986b) provides dates for his Local Group Horizon (III) of the Corded Ware Culture in Bohemia from human bone from graves at the sites of Vikletice and Široké Třebčice. Vikletice Graves 119/1963 and 58/1964 produced dates 1985 and 1910 ± 35 uncal. BC respectively. while Grave 5 from Široké Třebčice produced a single date of 2065 ± 30 uncal BC for the III Horizon.

49 Buchvaldek 1986a

50 Beran 1992, n.d.

graves (e.g. at Kolín and Prague-Vínohrad).[51] Given the dendro-chronological over-lap of the Early Corded Ware into the lower (calibrated) range of the Řivnáč, it is possible that these isolated finds represent traces of small infiltrating groups coeval with the later culture bearers, particularly in Central and East Bohemia (cf. Figs. 11 and 13).

The further development of the Corded Ware Culture is marked by two horizons (II and III), the latter of which produces the majority of Bohemian finds. The second (Central European) horizon is typified by a wide array of ceramic types, as well as by significant numbers of graves (e.g., Fig. 88). The ceramic inventory sees the continuation of amphora forms of the Pan-European horizon, although new Central European forms tend to be larger. Surface treatment is further enhanced by herring-bone decoration, while incised metope decoration evolves at times into ray-patterns covering the upper body of amphorae. Ground-stone axes of this II horizon are of a distinctive faceted type. Their centre of distribution in North Bohemia away from the main zones of prior Řivnáč Culture settlement should not pass without comment, nor should their association in cemeteries exclusively with male graves.[52] The final Local Group horizon (III) witnesses a further diversification of ceramic forms which include a range of new unornamented types of Pannonian origins (e.g., footed egg-shaped vessels and certain jug forms). Beakers also undergo a significant formal change at this time, developing high straight necks distinct from the lower body. Ax forms lose their faceted aspect, with the appearance of butt-ended "Bohemian Axes". The orientation of the Corded Ware Culture thus passes from North-Central to South-Central Europe during the course of its development from Find Group II to Find Group III times.

The Moravian Corded Ware represents an abbreviated sequence, with the vast majority of finds belonging to the III horizon. Only isolated traces of the I horizon appear in (Central and North) Moravia (e.g. an A-hammer-ax from Kladná-Žilín and a B1-type beaker from Němčice nad Hanou).[53] Significantly, an A-hammer-ax find in Layer B at Jevišovice suggests that the Jevišovice Culture persists in South Moravia into Corded Ware I horizon times.[54]

Apart from such isolated finds, there are about 324 graves of the III horizon in Moravia. Earliest examples include the find at Hulín in East Moravia, where a Dřevohostice-type typical

51 Buchvaldek 1967

52 Cf. distribution maps of Buchvaldek 1967, 1986b

53 Šebela 1981a, n.d.

54 Buchvaldek 1967

of the III horizon was found with a beaker of the II horizon. The former is a jug peculiar to Moravia, bearing III horizon Pannonian forms, as well as decorative properties after the II horizon in Bohemia.[55] Similar types with tall necks, sparse decoration and polishing appear towards the end of the sequence (Sub-Phases IIIb and IIIc), designated as (Pannonian) "Nagyrév Type A and C" jugs, of Carpathian Basin derivation.[56] The character of the Corded Ware Culture in South Moravia is so removed from the Central European groups bearing the same name that certain site assemblages of the former produce no corded ornamentation what-so-ever. For example at Krumvíř, a cemetery of mixed rite produces Letonice jugs, egg-shaped vessels and bi-conical amphorae typical of the Pannonian Nagyrév in atypical cremation graves assigned to the Late Local Group horizon of the Moravian Corded Ware Culture.[57]

Cemetery demography of the Corded Ware Culture

Because no indisputable settlement finds are known of the Corded Ware Culture in either Bohemia or Moravia, one must turn to the demographic analyses of cemeteries in order to arrive at an estimate as to the scale of local agricultural communities during the Corded Ware period.[58]

Most Corded Ware mortuary sites are comprised of groups of 20 or fewer graves, although these can form micro-regional clusters. The largest known cluster is Vikletice (265-285 mamsl), a site which extends extends over an area (ca.) 1250 m in diameter on a terrace overlooking the River Ohře in Northwest Bohemia. The 164 graves excavated here under salvage conditions form about eight separate concentrations, with (ca.) 60% of these lying within an area some 600 m in diameter (Fig. 87), and contain grave goods of the II and III horizons.[59] The orientation of all inhumations lies along an east-west axis, with the head facing south and the arms drawn in front of the chest, a practice common to Central Europe. What is

55 Šebela 1990

56 Dvořák and Šebela 1992

57 Šebela 1981b

58 Three find spots of the Corded Ware Culture in the Braunkohlegebiet of Northwest Bohemia are considered as Corded Ware settlements by J. Turek of the Archaeological Institute in Prague. These are in fact three shallow settlement pits with individual (secondary?) corded sherds mixed with settlement material of other cultures. Similarly at Palonín by Šumperk in North Moravia, two culture pits contained amongst other remains, a modest quantity of Corded Ware sherds; however, Šebela (n.d.) is more cautious about assigning a primary Corded Ware settlement status to these finds in view of their potentially secondary character (cf. Vencl 1994).

59 Buchvaldek and Koutecký 1970. Neustupný (1986) also provides a demographic assessment of the Corded Ware finds at Vikletice.

also curious is the regular placement (as in Bohemia as a whole and much of Central Europe) of male and female internments on opposing sides. All males are placed on their right side, with their heads facing west. Conversely, all females are placed on their left side, with their heads facing east. Hammer-axes and some pottery forms occur exclusively with male graves.

Because Vikletice produces certain imbalances in age and sex ratios, it follows that a proportion of the "living" population is not buried at the cemetery. These imbalances include an absence of young males along with a low representation of infants and youths. A contrast to Neolithic demography is provided by the Corded Ware mortality profile at Vikletice, which exhibits a significantly reduced mortality among females of child-bearing years, (i.e.) females of the Corded Ware Culture lived longer than their Neolithic predecessors due to a lower child-bearing burden. Thus these three lines of evidence, (1) the binary opposition of gender roles (focused within nuclear households), (2) the absence of substantial settlement remains (suggestive of dispersed households) and (3) the low birth-rate are suggestive of low densities of settlement population consisting of nuclear families. Because the total population at Vikletice at any one time is estimated to be maximally 20-25 individuals, the separation of burial clusters implies that immediate (10^{-1} km) communities are comprised of only one to two families.

Bell Beaker cultural sequence and funerary tradition

The Bell Beaker Culture in Bohemia and Moravia consists of a cosmopolitan assemblage of artifacts and properties. Bell Beakers also bear new decorative attributes typical to Atlantic Europe such as stamped-ornamentation in bands. Also of boreal origin, a range of costume artifacts appears, including jet v-perforated buttons and occasional amber ornaments. A mortuary emphasis on archery is seen with the appearance of arrowheads of flint and bone wrist-guards.[60] Pannonian cultural elements also widely appear in Bohemian and Moravian assemblages, for example copper daggers and the metope decoration on later Bell Beakers (derived from terminal Vučedol groups).[61] Most ceramic types also derive from this Pannonian aspect, comprised of (burnished) footed bowls, conical bowls, egg-shaped vessels and jugs, the so-called "Begleitkeramik".

The Bell Beaker period also brings a material reorientation of the funerary culture, with grave

60 Shennan 1976, Harrison 1978

61 Neustupný 1976, Schreiber 1973, Shennan 1978

pits dug along a north-south rather than an east-west axis. Gender positions of inhumations also reverse, males now lie on their left-hand side and females on their right. Notably, the cremation rite comprises (ca.) 23% of the mortuary assemblage in Moravia, where the mixed-rite is mirrored in so-called mixed-cultures, indicated by the significant presence of Kosihy-Čaka types derived from the North Balkans.[62] These exotic types comprise the decorated ceramics of the Kosihy-Čaka Group, for example pedestaled bowls with internal white-encrusted radial patterns. Because Kosihy-Čaka undecorated pottery is quite identical to the Bell Beaker Begleitkeramik, what this mixed-culture zone actually reflects are clinal changes in the typological composition of the decorated pottery component of assemblages only.

Problems of secondary culture definition should be considered, for the recognition of cultural affiliation has followed from the occurrence of individual types rather than assemblages.[63] This is best-illustrated by ceramic analyses of six features at Strachotín and one from Mušov in South Moravia, where types of the Kosihy-Čaka are mixed with Bell Beaker pottery.[64] It would appear that South Moravia is a cultural interaction zone between Hercynia and Pannonia.

Bell Beaker settlement population in Hercynia and Pannonia

Settlements of the Bell Beaker Culture consist principally of isolated homesteads, where ceramic finds are principally of Begleitkeramik types. In Bohemia, most direct domestic evidence consists of two post-built houses known at Kozly and one recently discovered at Liptice (Fig. 92).[65] The latter hut of six post-holes measures some 2.5 x 2 m, barely adequate space for a single family. A single shallow settlement pit was found with this hut, suggestive of a low (1-2:1) ratio between sub- and above-surface structures. Because the largest Bell Beaker settlement in Bohemia at Kolín VII consists of only 12 culture pits, it is suggested that occupations are comprised of about two to three coeval huts.

More substantively, Bell Beaker settlements in Moravia are represented by over 60 sites producing of up to six settlement features each.[66] The volume of settlement evidence increases

62 Hájek 1968, Havel 1978

63 Medunová-Benešová 1981b, cf. Klejn 1982 and Clarke 1976

64 Peška and Rakovský 1992

65 Hájek 1968, Teplice Museum n.d.

66 Dvořák 1989

as one progresses towards Hungary, where at Csepel Island near Budapest, over 100 features are known.[67] In Southwest Slovakia, there are also traces of the coeval Nagyrév Group within contemporary tel settlements, for example at Malé Kosihy.[68] Within the 90 m^2 investigated at Malé Kosihy by the Ipel (of 3,850 m^2), two storage pits were found, each more than a metre in diameter. The whole site might contain about 100 such pits, not unlike Csepel Island. Similar settlement traces were also discovered at Nitriansky Hrádok, which largely replicates the sequence observed at Malé Kosihy. Assuming then that a larger number (ca. 100) of settlement pits typify these sites at the southeastern periphery of the Bell Beaker cultural distribution, populations of (ca.) 30 individuals might be derived assuming a maximum site duration of eight generations and a ratio of two sub-surface features per domestic structure.[69]

Cemeteries and social structure of the Bell Beaker Culture in Bohemia and Moravia

The Bell Beaker Culture continues in some of the burial traditions of the Corded Ware Culture. At times the same cemeteries and even the same mounds of the previous Corded Ware Culture are used, for example at Čachovice in Northwest Bohemia, where three Late Bell Beaker inhumations cross-cut the graves pits of the III Find Group horizon.[70]

Typical of the Bell Beaker Culture cemeteries in Bohemia are the 21 graves from Brandýsek in Central Bohemia, containing 22 individuals of that culture. An assortment of primarily late Bell Beaker graves is found, in which most weapon finds (arrows and copper daggers) derive from left-sided (male) inhumations (e.g. Graves 71 and 73). Right-sided inhumations in turn contain bone ornaments and jugs typical of such graves. More atypical is Grave 22, where four posts of a mortuary house and rectangular grave pit occur. Within the grave, a right-sided inhumation typical of female internments is lain, as well as a copper dagger. An association of a feminine grave orientation with hunter-warrior artifacts is also notable at Radovesice in North Bohemia, there also occurs a rich burial pair (Graves 116 and 117), each containing decorated beakers and copper daggers. The apparently male grave (116) contains a larger dagger, in addition to an arrow, bow-pendant and wristguard. The right-sided inhumation (117, Fig. 91)

67 Schreiber 1984

68 Točík 1961b, 1981

69 Cf. Forenbaher 1993

70 Neustupný and Smrž 1989

also contains a copper awl, silver ring and gold head band.[71]

Like the Bell Beaker Culture in Bohemia, the Moravian finds are divided into earlier and later phases according to the presence of Maritime beakers on the one hand, and metope-decorated beakers and Begleitkeramik on the other. Early finds of the above described phenomenon include Grave 19/70 from Ostopovice in Brno-Venkov (Fig. 89). This grave contained an unusual decorated bowl, two Maritime beakers, six amber beads, 20 v-perforated buttons and a boar's tusk, much like finds from rich hunter-warrior graves of males. The inhumation here was placed on the right-side, and importantly, anthropological analyses establish that the skeleton belongs to a woman aged 20-30 years. Other right-sided inhumations with copper daggers (and anthropologically established as female) occur at Ledce, in Graves 1/36 and 1/62 (Fig. 90).[72] Affirmatively, Záhlinice in Middle Moravia also produces a single grave of a right-sided inhumation (48/89), which also contains four vessels (including three Maritime beakers), a bone wristguard, four copper spirals, a small copper dagger and a boar's tusk pendant. Anthropological analyses determined that the skeleton from Záhlinice belongs to a mature female (50-60 years).[73] The inclusion of females into the rich grave group, as well as an increased absolute wealth differential, suggests that inter- rather than intra-familial social distinctions are becoming more important with the transition to the Early Bronze Age.

Adaptations of Eneolithic agriculture in Central Europe

The Eneolithic epoch brings an adjustment of pre-existing Neolithic crop regimes rather than the introduction of new (formal) cultigens. Emmer wheat remains the primary cultigen, not only in the former Czechoslovakia, but also in neighbouring Poland and Hungary, with einkorn as a common, if minor admixture.[74] The most important adjustment is the increased use of both naked and hulled six-row barley (*Hordeum vulgare* and *H. v. coeleste*), particularly in Bohemia, where its representation from Neolithic times increases from 11 to 34% of sampled sites. Still higher proportions of barley are to be encountered in Poland, where it rivals emmer in importance, and eastern Germany, where it is the most important crop.[75] Finds of barley in

71 Teplice Museum n.d.

72 Dvořák 1992

73 Dvořák et al. 1992, Dobišková 1992

74 Wasylikowa et al. 1991, Litýnská 1990, Klichowska 1979

75 Schultze-Mötel 1969 and Wasylikowa et al. 1991

warmer Slovakia are less common, appearing at only 14% of sampled settlement sites.[76] The pattern of these finds is understandable after the relative edaphic requirements of wheat and barley, the latter being a hardier crop resistant to colder temperatures than wheat (along these lines, the establishment of structures for the precise calculation of the summer and winter solstice at Makotřasy might also be seen as an adaptation to more severe agro-climatic conditions).[77] Thus with the periodic cooling experienced during the Eneolithic, prehistoric farmers adjusted their crop components in observation of this fact.

Respecting *ad hoc* crops, recent botanical finds from Svodín should be considered, namely quantities of *Amaranthus sp.*, *Chenopodium album*, *Ch. glaucum* and *Ch. hybridum* recovered in three Middle Eneolithic features.[78] These finds might reflect an "informal" exploitation of the drought-resistant qualities of these wild taxa, particularly in lower-altitude areas too dry to reliably support a "formal" grain crop.[79] Further evidence for the *ad-hoc* exploitation of informal crops also comes from 118 macro-fossils of *Panicum miliaceum* in one feature.[80] Although less productive than wheat or barley, millet requires only a 60 to 90 day growing season, a fact which favours its (mini-max) exploitation as a secondary food source.[81] Millet becomes a major crop only in the Late Bronze Age.[82] Amongst notions to be discounted in this section is the concept of a purely pastoral Late and Terminal Eneolithic epoch. The presence of sickle-gloss from corn-reaping on flint blades of both the Corded Ware and Bell Beaker Cultures argues against such.[83]

An Eneolithic use of the traction ard is clear in the light of the plough-marks preserved under the Funnel Beaker long barrow at Březno in Northwest Bohemia. An assay of 3140 ± 45 uncal. BC from this site would place these traces in the Baalberg Phase. As at Sarnowo, the pattern produced by the ard marks at Březno indicates the use of parallel- rather than cross-

76 Wasylikowa et al. 1991, Hajnalová 1989, 1990, 1993

77 Zohary and Hopf 1988, cf. Pleslová-Štichová 1980, 1985

78 Hajnalová 1986

79 Cf. Turrill 1929. Notably, amaranth becomes a <u>formal</u> crop in prehistoric Central America.

80 Hajnalová 1986

81 Zohary and Hopf 1988

82 Hajnalová 1990. The etymology of "millet" in the Indo-European languages is complex. That it was considered as an "alien" crop by the Indo-Iranians is suggested by the term "Priyangus" or "millet-eaters", applied by Ancient Aryans to the native Dravidians of North India (Hoops 1905).

83 Popelká (pers. comm., 1992) reports 17 cases of sickle gloss among 287 lithics of the Corded Ware Culture in Bohemia. Bell Beaker blades on display in the Archaeological Museum at Kraków also bear similar traces.

ploughing techniques.[84] Middle Eneolithic representational evidence for teamed oxen from Vysočany in South Moravia also attests to the use if some form of harness, while the ritual burial of oxen in pits in the territories of Moravia and Slovakia betrays a ceremonial regard for these Middle Eneolithic beasts of burden (cf. Homolka terra-cotta idols). Also on the basis of the pan-Central European evidence, both cattle and sheep were exploited for milk.[85]

Wool production in Central Europe is a telecratic aspect of the secondary products economy to be exploited first in either the Eneolithic or the Bronze Age. The use of sheep's wool for weaving is dependent on access to the long-haired breeds of *Ovis aries*, the direct detection of which is problematical after osteological material. Osteologically, one would expect an assemblage from a milking economy to exhibit delayed mortality for females only, while a wool-based economy would encourage the maintenance of most of the herd until old age. In this respect, age and sex profiles from the sub-Alpine region are more indicative of dairying than wool production, for example in the ovi-caprid assemblage at Ledro.[86]

Although it is clear that the household textile industry of the Eneolithic is very active (Hlinsko alone produces some 870 spindle whorls), it remains possible that the development of flax cultivation accounts for the common occurrence of spindle whorls here and elsewhere.[87] In this light, finds of *Linum usitatissimum* in mass quantities from Hlinsko are instructive.[88]

The further "extensification" of agricultural communities into smaller, more dispersed units is a general tendency exhibited during the Eneolithic epoch.[89] This micro-regional expansion onto the inter-fluves and uplands encourages an increased manufacture of ground-stone implements designed for wood cutting (cf. Fig. 93). This development in turn induces a more intensive use of surface exposures of lithic raw material and hence the development of pit and gallery mining. Gallery mines are well known from South Poland, for example at Krzemionki and Świeciechow. Analogous sites are known from North Bohemia at Tušemice (and perhaps Skršín). Tušemice itself produces five shafts some two to three metres deep, containing quartzite debris, antler picks and the remains of a fire place. A radio-carbon date from Shaft 5

84 Cf. Pleinerová 1981 and Dąbrowski 1971

85 Barker 1985, Sherratt 1986

86 Barker 1985

87 Milisauskas et al. 1990. Ibid. also cite an increase in numbers of spindle whorls discovered per settlement object as a ratio increasing from 0.5:1.0 to 3.0:1.0 during the course of the Funnel Beaker Culture in South Poland.

88 Pavelčík 1983, cf. Whittle 1985

89 Pavúk and Šiška 1980, Kruk 1980, Bogucki 1988

of 2818 (+/- 100) uncal. BC is indicative of an earlier Eneolithic exploitation of Tušemice.

Kinship organisation and the agricultural economy

Central to the traditional understanding of the social organisation of Eneolithic agrarian society is the concept of the replacement of large corporate groups by smaller patri-focal and family-based units, the emergence of so-called "patriarchal society".[90] Respecting an economic impetus for this development, the adoption of the ox-drawn traction-ard has repercussions on the annual distribution of farming labour, leading to an imbalance in the requirements for sod-cutting and grain-harvesting. The area ploughable by ox and ard in a day ranges between 0.1 and 0.3 hectares, while only 0.02 to 0.05 hectares of arable land can be cut by hand by one man in one day.[91] Because five times the labour is required to perform the task of harvest in comparison with that required for planting, one would expect the Early Eneolithic farmers to parcel out crops over the agricultural year in order to distribute that labour. Thus, mixed crop assemblages (a wheat-barley dyad) might be understood in terms beyond an adaptation to climate change.

The dispersion of Eneolithic agrarian communities through the landscape reflects a lapse of the need for large pools of labour for soil preparation. A limit on the acreage cultivated would depend then on the ability to parcel-out the labour of the harvest over a longer period, assuming two harvests per year (one of wheat, one of barley). Allowing two weeks for each harvest, the maximum area cultivable by a nuclear family with three working members would range between 1.7 and 4.2 hectares, more than adequate for subsistence. Released from the need to concentrate large pools of human labour, one might expect farmers to disperse into community areas, taking full advantage of the agricultural landscape. Mitigating against this dispersive tendency would be needs for group defense and viable mating networks.

Given the small Corded Ware populations reconstructed on the basis of analyses at Vikletice, an increased importance of nuclear family groups might be assumed. The gender-based binary opposition of burial position, as well as the mutual exclusiveness artifact sets is absolute, in contrast to Middle Eneolithic funerary structural patterns (see above).

With the Bell Beaker Culture, a gender-based burial orientation persists, although curiously, all categories are inverted. The formerly male attribute of right-handed inhumation is now

90 Neustupný 1967

91 Halstead 1995

attributed to females, while the converse now falls to males. Orientation of grave pits also changes to a north-south axis. Furthermore, the occasional appearance of female warrior-hunter graves may reflect the emergence of inter-family ranking during the Terminal Eneolithic.

Population dynamics and the evolution of Eneolithic settlement

Populations of individual Eneolithic farming communities are small, and in all cases, below the threshold of biological sustainability. Requirements for a mating population of a minimum of (ca.) 500 individuals necessitate that certain kinship networks would need to be extensive,[92] particularly respecting the early and late periods. During the Middle Eneolithic, local populations increase in terms of density, a process most precocious in Pannonia.[93]

Summary site population reconstructions are thus presented in Table 9.1 (below). Tentative Baalberg and Channeled Ware site populations in Pannonia are derived from the rate of tell-like deposition of these periods relative to that of the Jevišovice Culture at the epynomous site (0.5), and then multiplying this factor by a representative (Middle Eneolithic population) constant of 175 inhabitants derived from the Jevišovice Culture occupation at Grešlové Mýto.

Table 9.1. Inhabitants per settlement (cemetery group) for the Eneolithic in two biotic provinces

Chronological Period	*Hercynia*	*Pannonia*
Fürchenstich (Lengyel IV)	n/a	ca. 20-40 (cf. Note 94)
Baalberg Phase	ca. 25-30	ca. 80-90?
Salzmünde Phase	ca. 30-60	n/a
Channeled Ware	ca. 50?	ca. 80-90?
Řivnáč-Jevišovice Culture	ca. 160	ca. 175
Corded Ware Culture	ca. 5-10 (20-25 per cemetery group)	n/a?
Bell Beaker-Nagyrév Culture	ca. 10-15	ca. 30?

It would thus seem that communities of the Early Eneolithic would require about 20 local sites to complete a sustainable minimal tribal population of 500 inhabitants. In spatial terms, such a

92 Wobst 1974, 1976

93 Cf. Rulf 1979

minimal population might occupy (ca.) 100 km of a dendrical tributary river network, which when applying a constant of (ca.) 0.5 km^2 area (under 350 mamsl) per 1.0 km of fluvial network, results in a minimal tribal territory exploiting a primary agricultural settlement zone of some 50 km^2, assuming that settlements are spaced at (ca.) 5 km intervals (as is evidenced in the Prague area). The phenomenon of cultural inter-penetration noticeable from the beginning of the Eneolithic sequence might be consequent to the establishment of open if regional networks of population exchange. Such networks might also have favoured the direct biological assimilation of "relict" hunter-gatherer groups.[94]

The Middle Eneolithic witnesses significant growth of intra-site population, so that only three to six settlements would suffice to form a sustainable mating population. Spaced at shorter intervals, one might conclude that only 12-24 km of fluvial network, or (ca.) 6-12 km^2 of primary settlement (under 350 mamsl) might suffice to support such a minimal tribe (although there are extensive unoccupied areas between populations, cf. Fig. 12). Culture zones also variegate at this time, reflecting perhaps a cultural particularism resulting from denser, less-extensive networks of population exchange.

Significantly, limited evidence of tribal conflict also appears in the Middle Eneolithic period, with widespread fortification of sites (a phenomenon which also begins somewhat earlier in Pannonia, where local population densities are higher, cf. Rmíz, Fig. 80). Direct evidence for one "raid" has been cited with respect to mass arrowhead finds from Křepice in South Moravia. From Bohemia and Slovakia, traces of cut-and-smashed human bone in settlement features and finds of mass burials in settlement features also occur as a relatively coherent horizon dating to this period of proposed tribal regionalisation. In relative environmental terms, this middle period represents the Eneolithic agro-climatic maximum, after lake-level, fluvial morphologic, ^{18}O-fractionation, alpine tree limit and karst-inundation area occupational evidence.

The Late Eneolithic period produces new settlement conditions, with local communities so small as to lead to the establishment of very extensive mating networks. These would probably cross-cut prior tribal boundaries with different specific kinship systems, leading perhaps to a pronounced awareness of gender opposition, as is evidenced in the Central European funerary culture pattern. Given the placement of individual small communities at somewhat denser

94 The Jordanov or Lengyel IV population estimate follows from Jelšovce in Southwest Slovakia (Pavúk and Bátora 1995). Within the 3.75 hectare excavated area, some 26 house plans were recovered in part or *en toto*. The houses at Jelšovce are large, up to 21.5 m in length. Their bipartite division as well as their size (exceeding 100 m^2 in internal area) is suggestive of their occupation by dual-family co-residential groups. Given the duration of occupation (of about 300 years), only 1/12 of the domiciles may be coeval, assuming a generation-long duration of house-use (cross-cutting relationships are common). It seems probable that about 2/3 of the site has been exposed. Following from these grounds, a population level at Jelšovce would have averaged 20-40 individuals during the Lengyel IV period.

intervals along a drainages (ca. one per two km), a fluvial network of 100-200 km, or a tribal territory extending over a land area of 50-100 km^2 (under 350 mamsl) would be required to support a single tribe. The spatio-cultural expression of such an open network would rival those of (complex) hunter-gather techno-complexes in its extent, and explains in part the great spatial extent of the Late Eneolithic Cultures in Central Europe.

One might view these cultural expansions then as "migrations by infiltration" through density-dependent population dynamics rather than the genesis and expansion of particular *ethnoi*.[95] These expansive cultural networks encounters greater "alien equivocation" in the more densely populated Carpathian Basin, and here the Corded Ware Culture in particular loses its cohesion. The nature of the Bell Beaker cultural expression is complex, given the potential for leading clans to achieve wider zones of inter-action. This tendency towards incipient social ranking anticipates socio-political developments in the Bronze Age.

Review of reconstructions of Eneolithic settlement populations

Settlement population reconstructions of the Eneolithic derive from (direct) household and (indirect) sub-surface finds. Limited observations allow for a tentative derivation of sub-surface feature to domicile ratios at 2:1 for the Early Eneolithic (Figs. 81-83), 1:1 for the Middle Eneolithic (Figs. 84-6) and 1-2:1 for the Late Eneolithic (Fig. 92). Only in the earliest Eneolithic period (Baalberg-Michelsberg-Jordanov-Fürchenstich) are multi-family long houses evident. Subsequent single-family huts represent then a fissioning of larger co-residential groups discernible since Early Neolithic times. Significantly, larger population agglomerations of the Middle Eneolithic are still comprised of collections of single-family huts. An internal consistency between the Middle Eneolithic population reconstruction directly derived from hut finds at Homolka and that derived indirectly from the presence of minimal domestic clusters of sub-surface features at Grešlové Mýto furthermore gives confidence in the reliabilty of the ratio- and accumulation rate-methods. Generally larger Pannonian population reconstructions vis à vis those of Hercynia are also supported by the observed net-accumulation of anthropogenic sediments at numerous Eneolithic sites in the former zone (e.g., Jevišovice, Vysočany, Křepice and Grešlové Mýto). Eneolithic tell-like sites are very rare in Bohemia, and are known only from Slaný.

95 Cf. Neustupný 1982

Eneolithic settlement archaeology and geo-botany

Primary pollen sites of the Eneolithic are of poor data quality due to limitations of dating and a low volume of evidence. Pollen spectra of probable Early Eneolithic date from Konobrže in North Bohemia are indicative of a low-intensity agricultural regime after the total preponderance of pastoral (syn-anthropic) pollen types. By comparison, possible Eneolithic (pre-Bronze Age) spectra from the principal site of Vranský potok express a singular but emphatic peak of primary cultivation at 3.3%. This latter event might be concurrent with an episode of intensive cultivation by communities of the Middle Eneolithic Řivnáč Culture. This short phase of maximal cultivation is followed by a longer phase of woodland regeneration, coeval perhaps with the Late and Terminal Eneolithic periods of the Corded Ware and Bell Beaker Cultures.

10. Bronze Age agricultural settlement of Bohemia, Moravia and Slovakia

Prehistoric settlement in the Bronze Age of the Czech and Slovak Republics is reviewed in this chapter, differentiating between the cultural histories of the Hercynian and Pannonian bio-geographic zones (Figs. 94-95). Culture history recognises an early, middle and late period associated with an array of cultural appelations. Within this general sequence, the "Classical" (or terminal) Early Bronze Age after 1950 cal. BC. and Late (Urnfield) Bronze Age after 1500 cal. BC see the diffusion of Pannonian cultural elements into Bohemia and beyond together with reconstructed phases of maximal agro-climate (i.e., with high positive degree-day differentials).

After settlement archaeology, earliest Bronze Age hamlets give way to larger, sometimes fortified villages in the "Classical" period. A decline in site population concentration is then pronounced in the Middle Bronze Age (known primarily for its mound cemeteries), after 1700 cal. BC. Finally, an emphatic population growth is then traceable in the Late Bronze Age period, often concentrating part of a "regional polity" population into larger fortified villages.

Social phenomena correlated with periods of settlement concentration include inferred systems of rank and evidence for raiding or warfare. Together with material and osteological evidence for raiding or warfare, evidence for ranking comes principally from settlement phases transitional towards the formation of regional polities to be reconstructed below. A cultural structuring of this evidence also suggests that "direct competition" occurs in relation to the acquisition of personal status or an enigmatic cultic focus rather than competition for material resources. "Pacification" phases sometimes <u>follow</u> such "conflict horizons" with an emergence of stable, ranked regional polities, particularly during the long cultural continuum of the Urnfield period.

Early Bronze Age cultural sequence

The Earliest Bronze Age "Proto-Únětice Culture" (1800 uncal. BC, or 2250 cal. BC.) of Bohemia and Moravia represents a development of the Late Bell Beaker Culture. The burial rite, like that of the Bell Beaker, is characterised by north-to-south oriented inhumations, although the Late Eneolithic practice of gender specific rites is discontinued west of the River Morava. Settlement sites *per se* are rare and of modest size. Material culture also forms from a Bell Beaker substrate (Begleitkeramik), although further east, a quite different sequence is encountered (see below). Within Únětice Culture assemblages, there develops an array of well-burnished ceramics which are first smoothly profiled, and then develop carinated forms such as the characteristic low-handled-cup. Horizontal and vertical patterns of simple incised lines (sometimes bearing white encrustation) are developed as a decorative attributes through the Únětice sequence. In Bohemia, "horizontal stratigraphy" at Polepy near Kolín also allows for a six sub-phases to be recognised (ca. 1800 to 1500 uncal. BC).[1] This sequence is somewhat abbreviated in Moravia, where five sub-phases are recognised (ca. 1800 to 16/1550 uncal BC).

At the beginning of the Early Bronze Age sequence east of the River Morava, areas of prior Bell Beaker settlement witness the appearance (at ca. 1800 uncal. BC) of the epi-Corded Ware "Chłopice-Veselé Group", an assemblage of apparent South Polish origin.[2] This group represents the first phase of the Nitra Culture (which is broadly coeval with the earlier Únětice sequence).[3] The full ceramic assemblage (deriving primarily from graves) of the Nitra Culture includes a small range of cups, pots and bowls, sometimes bearing vertical zones of impressed corded-ornamentation. Most impressive, however, is its copper, bone and stone tool assemblage. Arsenical copper artifacts are comprised of small daggers, bracelets and willow-leaf ornaments, while bone wrist-guards for archery, beads of bone, pendants of boar's tusk and well-made flint arrow-heads also occur. Notably, burials of the Nitra Culture retain an attenuated Corded Ware burial rite of right-side male and left-side female inhumations discontinued in most of Central Europe for three (radio-carbon) centuries. The final Nitra phase (prior to 1600 uncal. BC) betrays western influences in evolved Únětice ceramic types, prior to the evolution of the so-called Únětice Phase of the Mad'arovce Group.

Upon a substrate of eastern Únětice and Hatvan elements, a new cultural circle appears towards the end of the Early Bronze Age (ca. 1600 uncal. BC) in Pannonia, that of the Mad'arovce and Věteřov Groups in Slovakia and Moravia respectively.[4] That these groups should be considered as part of a singular culture group is evident in the general composition of the pottery assemblage, which includes a variety of jugs, cups, bowls, pots, amphorae and storage vases exceeding the range encountered in the Únětice Culture. Decorative attributes are polythetical in distribution, with "micro-warts" common to the eastern Mad'arovce Group and "cross-channeling" common to the western Věteřov Group. Certain formal types are also particular to

1 Cf. Moucha 1954

2 Peška 1989, Peška and Šebela 1992

3 Točík 1963

4 Cf. Tihelka 1960, Točík 1981

restricted regions, for example, the "B2b cup" (influenced by the Únětice low-handled-cup?) common to Mad'arovce sites in the Nitra and Váh valleys is not to be found among eastern sites of this group.[5] Further (northern) peripheral groups of this circle occur around Hradec Králové in East Bohemia as well as in Upper Silesia (the Polish "Nowa Cerekiew Group"). Significantly, these boreal groups possess fewer types of the full Věteřov range, while in Bohemia, the Late Únětice Culture also possesses a limited range Věteřov types which is indicative of a limited Pannonian cultural "influence". Inter-regional differences in these Early Bronze Age assemblages are thus not constituted by a range exclusive types, but rather by a polythetical appearance of individual types. The final phase of the Early Bronze Age (ca. 1450 uncal. BC) presents a chronological problem. This "Übergangshorizont" (or Reinecke Bronze Age A2/B1) is constituted of "mixed" assemblages of Early and Middle Bronze Age types. Its closed assemblages include settlements of Prague-Bubeneč and Veselé-Trnava (in West Slovakia)[6] as well as Tumulus Grave 62 at Nová Hospoda (Southwest Bohemia).[7] This horizon is considered here as the end period of the Early Bronze Age.

Settlements of the Early Bronze Age in Moravia and Slovakia

Like the Late Eneolithic Cultures, settlements of the earliest Bronze Age are relatively rare. Among Nitra Culture settlements, Přerov in East Moravia and Čataj in Southwest Slovakia produce only isolated settlement pits (Fig. 95); while notably, the pit at Čataj produces finds of daub with straw impressions.[8] A further find of a single settlement pit (Feature 1) at the Nitra Culture cemetery of Jelšovce on the Nitra contains encrusted pottery of the Late Kosihy-Čaka group, inviting the possibility that some Nitra Culture cemetery users may have used Kosihy-Čaka ceramics at their settlements sites.[9] Also within the city of Nitra, salvage excavations on

5 Cf. Točík 1993, Tihelka 1960

6 Friedrichova 1982, Benkovsky-Pivovarová 1976

7 Čujanová-Jílková (1979). Cf. Jílková (1958) regarding the find of a Late Únětice ceramic storage vase and an Early Tumulus bronze pin in a single grave from Tumulus 62 at Nová Hospoda. Also in the case of Borotice in Southwest Moravia, graves of the Věteřov Culture (B.A. A2) placed in tumuli represent first internments alongside secondary graves of the Early (B.A. B1) Tumulus Culture (Stuchlík 1990a, 1992b).

8 Peška and Šebela 1992, Pavúk 1981

9 J. Bátora (pers. comm., 1993) would disfavour such a notion; however, his own chronology (Bátora 1989) implies such a possibility of bi-culturalism in Early Bronze Age Middle Danubia.

Priemyslová street have revealed a small group of settlement pits of the Chłopice-Veselé Phase, representing habitations of one or two domestic groups.[10] Large cemeteries of the Nitra Culture are suggestive of larger and longer-lasting populations, for example at Holešov near the River Morava, where 385 graves of the Nitra Culture occur.[11] Including children, one might construe a local community of 50-60 individuals in the environs of Holešov.[12] Still larger sites of the Nitra Culture are known, for example the 500+ graves from the sites of Jelšovce and Mýtna Nová Ves in Southwest Slovakia.[13]

Lowland settlements of the Únětice and Věteřov Groups in Moravia are poorly documented, while Únětice house-plans are virtually unknown, save for a single (8 x 5 m) post-structure from Velešovice.[14] Otherwise, only the ubiquitous settlement pit is known from sites of the Únětice period. The greatest number of sub-surface features known from one Únětice site derives from Šatova in South Moravia, where 180 pits occur.[15] Applying a constant ratio of pits to huts observed (4.25:1, cf. Note 15 below) to the three generations of Classical Únětice occupation at Šatova, a settlement of 14 households can be construed, or *circa* 70 villagers.[16]

The relative concentration of (later) Věteřov Bronze Age settlement features is also illuminating, with Mušov producing 19 substantial features of Věteřov date within a 150 m^2 area.[17] From this, one might imagine that Věteřov lowland sites contain populations at least as

10 Bátora 1993, cf. Neustupný 1969

11 Ondráček and Šebela 1985

12 Cf. Neustupný 1983

13 Bátora 1990, 1991

14 Podborský 1993

15 Ibid. At Nitriansky Hrádok, the existence of ca. 80 remains of Mad'arovce houses juxtaposed to 341 settlement pits is observed. The former figure is adjusted for additional finds of domestic ovens as well as clay-floors, so that a working constant of 4.25 pits per nuclear family-generation might be proposed from finds at this site. Affirmatively, finds from Blšany produced nine settlement pits at a 50 m remove from a long-house of Early Únětice Culture date. The dimensions of this singular structure (17.3 x 6.1 m) would be large-enough to contain a co-residential group of 10 after Naroll's (1962) method, equal to two nuclear families. A working constant of 4.5 pits per nuclear family-generation thus derived from these finds closely approximates that at Nitriansky Hrádok.

16 The Únětice Culture becomes more abbreviated as a cultural sequence as one proceeds from west to east. The period of "Věteřov influence" in the final phase (6) of the Únětice Culture in Bohemia is thus somewhat later than the "establishment phase" of the Věteřov Group in Moravia (cf. Tihelka 1960). In Slovakia, the "Early Únětice Culture" comprises the final phase of the "Nitra Culture", coeval with Bohemian Únětice Phase 4 (cf. Točík 1963 and Ondráček and Šebela 1985). The final "Únětice-Mad'arovce Phase" represents the initial phase of the Mad'arovce Culture in the valleys of the Váh and Nitra, where it is broadly coeval with Phase 5 of the Bohemian sequence.

17 Stuchlík 1992b

great as those encountered in the Únětice Culture.[18] Comparatively of the eight hill-top settlements of the Únětice Culture which have been discovered in Moravia, all are unfortified,[19] while most of the 17 known hill-top sites of the Věteřov Group in Moravia are fortified.[20]

Elaborate Věteřov fortifications take the form of v-shaped ditches (one at Blučina-Cezavy reaches a preserved depth of five metres) and walls (e.g. the still-extant 1600 m circuit at Hradisko near Kroměříž). Also belonging to the latter class are the Věteřov finds from Přerov in East Moravia, where a circuit-wall (still 1.8 m high) overlooks the flood plain of the River Bečva. The enclosure at Přerov also contains clay floors of domiciles.[21] A further bipartite structure some 40 by 7 m found at Pavlov in South Moravia is more suggestive of a degree of social stratification, as less impressive household remains were also found at this Věteřov site.[22] Thus in the regional context of elaborately fortified centres, the aggregate of Věteřov settlement evidence is suggestive of relative social complexity. Further evidence of settlement and social complexity is also forthcoming in the case of the closely-related Mad'arovce Culture.

Fortified settlements of the Mad'arovce Culture

Best-known of the settlements of the Mad'arovce Culture in West Slovakia is the fortified village at Nitriansky Hrádok by the River Cítenka. Nitriansky Hrádok is a tel consisting of temporally dis-conformative deposits from dating from Late Neolithic times until the Late Iron Age. Prior to the Second World War, these deposits extended over an area of some 1.7 hectares, of which 0.75 hectares have seen excavation, (i.e.) 43% of the original site. The earliest Mad'arovce Culture layer (of the Únětice-Mad'arovce Phase) was partially leveled during the succeeding Classical Phase of occupation, which produced the bulk of settlement debris (in

18 Hypothetically, should we allow a one hectare extent for the Věteřov settlement at Mušov and a constant rate of feature representation, about 1200 sunken features of Věteřov date might have been established at this settlement site. A similar number of settlement features can be predicted for the site of Jędrzycowice of the Nowa Cerekiew Group, on the basis of more extensive excavation (Gedl 1990).

19 Stuchlík 1982

20 Stuchlíková mentions ten fortified localities in her (1982) work. Since this time the rescue excavations at Přerov and Pavlov in East and South Moravia respectively have added a further two sites to this list (Staňa 1988 and J. Peška pers. comm., 1995).

21 Staňa 1988

22 J. Peška pers. com., Winter 1995

which 40-50 cm [or more] of anthropogenic sediment is deposited in most places).[23]

The juxtaposition of the Classical Mad'arovce culture layer atop remains of the earth-and-timber wall demonstrates that the site was unfortified during the height of its occupation, although the v-shaped ditch 10 m wide and 4.5 m deep remained in use after this wall had been leveled (without traces of burning). Settlement finds within include 341 culture pits, some of which were very large indeed, for example Feature 3 is dug 4.5 m deep and 6.4 m wide (Figs. 143-4). If such features served as storage pits, the grain contained would be sufficient to feed a small village in times of need (i.e. used for central storage?). Most of these sub-surface features date to the Classical Mad'arovce period, although nine Early Mad'arovce culture pits also occur, two of which contain white-encrusted North Pannonian Ware. The production of horse cheek-pieces out of antler along with clay models of spoked wheels also suggests the use of the wagon and/or chariot.[24] Crucial for palaeo-demographic inferences are the 40 house plans recovered, each with (unburnt) clay-floors, shallow post-holes and a small (burnt) clay oven (Figs. 97-8). Because a further 40 finds of such ovens were made without clearly patterned house remains, it is most probable that only 50% of the unburnt clay floors have been detected in the thick occupation layer.[25] It is unlikely that these "extraneous" ovens were used in pottery making, as the latter function was served by four large (extra-domestic) bee-hive kilns.

The houses themselves occur at varying depths in the cultural layers, suggestive of their dia-chronic aspect, although most date to the Classical Phase, a period of (max.) one century. Complex stratigraphic relationships are observable, with clay floors overlying storage pits (e.g. Hut 1) or floors of other houses (e.g. Huts 5 and 2), and also significantly, the re-flooring of individual houses (e.g. Hut 8). Thirty-seven of the houses recovered date to the Classical Phase, only Huts 15 and 39 are earlier, while Hut 11 dates to the Late Phase.[26] These huts are regular in plan (ca. 4 x 5 m in area), although a singule hut (35) contains three rooms, perhaps the house

23 A rate of deposit of ca. 0.45 cm per annum and a maximum duration of the Classical Phase to a century span is assumed. Following from the population estimate of ca. 215 to be derived for Nitriansky Hrádok over its 1.7 hectare original area, one arrives at a populational-volumetric rate of accumulation of ca. 0.35 m^3 per inhabitant per annum. Comparing this to the inferred rate of deposit at Grešlové Mýto, where an Eneolithic culture layer 20-50 cm thick was deposited over 3.5 hectares over 250 years by an estimated 180 inhabitants, one arrives at a calculated rate of ca. 0.27 m^3 per inhabitant per annum (Točík 1981, 1961).

24 A vase at Velké Raškovce in East Slovakia for example bore an engraved design of a chariot (Furmánek et al. 1991).

25 Burnt clay ovens are certainly easier to detect than unburnt clay floors and post-holes on a tel-type site. Despite the control of A. Točík's excavation, it is unlikely that the industrial pace of work at Nitriansky Hrádok allowed for the full detection of clay floors and relatively small posts of these quasi-adobe houses of the Western Slovak Early Bronze Age.

26 It is most-likely that the small number of recovered Únětice-Mad'arovce Phase houses results from the leveling of the site at the establishment of the Classical Phase occupation. Likewise it is possible that Late Mad'arovce huts have been exposed to erosion follows the Early Bronze Age abandonment.

of a higher-ranking individual.

If only 50% of houses are recovered (*a r* index = 0.5), each serving 25 years (a conservative estimate when considering examples of re-flooring), an average of 18.5 houses would have been extant within the excavated area during the Classical Phase of the Mad'arovce Culture. Because 57% of the site remains unexcavated, it follows that about 43 Classical Mad'arovce houses are simultaneously extant on the entire site, yielding a total of *circa* 215 inhabitants.

Geography of possible Mad'arovce regional polities

The relationship of fortified villages to unfortified settlements of the Věteřov and Mad'arovce Groups is better understood in the latter group of West Slovakia.[27] First it must be observed that fortified settlements themselves are not always fortified for their entire period of occupation. The earliest fortified settlements are those of the Hatvan-Mad'arovce Culture from the River Ipel. The phenomenon of fortification then spreads westward to the Nitra and in one case as far as the Váh during the earlier part of the Mad'arovce Culture, for example at Jelšovce (north of Nitra) and Ivanovice (in the Váh valley).[28] A later series of sites from the western districts of Trnava and Galanta are known from Hradisko near Veselé, Zámek by Boleráz, Pri Mylne by Budmerice and Poddivoč by Hoste of the Classical Phase, contemporary to the wider initial expression of the "fortified settlement horizon" amongst the Nowa Cerekiew and Věteřov Groups to the north and west. It would appear that the construction of fortifications reflects a reaction to regional conditions of tribal "unrest" diffusing from east-to-west. Importantly, all remaining fortifications fall into disuse at the end of the Late Věteřov-Mad'arovce Phase.[29]

The spatial patterning of the fortified sites is suggestive of relatively small territories varying from 7 km in diameter in the east (Ipel valley) to 25 km in diameter in the west (Váh valley), with a mean value of 10 km which approximates the size of hypothetical peer-polities in the central valley of the River Nitra.[30] The specific relationship of fortified to unfortified sites is often poorly-defined, although three sets of possible relationships may be inferred on the basis of

27 Cf. Shennan 1986

28 Točík 1982, cf. Furmánek and Marková 1992 and Kalicz 1984

29 Exceptions include (possibly) Kamenín and a handful of sites on the Ipel. Data presented by Ožd'áni (1986) on a macro-regional Bátora (1993) on a micro-regional scale suggest that population levels declined significantly during the Middle Bronze Age of the West Slovakian Carpathian Tumulus Culture. Cf. also Bintliff 1984c

30 Cf. Točík 1982, Bintliff 1984 and Bátora 1993

known settlement distribution:

A. Fortified settlements as independent entities within 3.5 km radius (Ipel River valley)[31]

B. Unfortified settlements as independent entities (isolated surface finds and exposures)[32]

C. Fortified settlements in association with a network of unfortified sites within a 5-12 km radius (Nitra-Hradný Kopec, Nitriansky Hrádok, Kamenín and Hoste, i.e. valleys of the Rivers Nitra and Váh)[33]

It is probable that Case B reflects a poor state of research given the greater relative visibility of hill-fort sites. Case A implies a "lack of complexity" only in that greater population densities are achieved precociously in the sequence, with a complete migration into fortified sites and an abandonment of the unenclosed "lower" tier of the settlement hierarchy. In Case C, social and ideological needs of defense occur later *vis a vis* lower initial population densities. Also belonging to Case C are fortified sites which undergo a phase of de-fortification while still at the height of their occupation, for example at Nitriansky Hrádok, where the earth-and-timber fortification wall is leveled during its Classical Phase, must itself be a politically-directed event.

The size of subsidiary village sites represent an unknown factor, although 30 midden pits recovered from test excavations of an unenclosed occupation near the fortified site at Kamenín reflects a substantial settlement. Notionally one might assign to such unenclosed places a population value of about half that of the fortified sites.[34] Best-documented amongst these micro-regions is that at Nitra itself, where continuous sub-surface salvage excavations have taken place within the city limits (Fig. 99). Within this micro-region, the existence of a fortified settlement on the site of Hradný Kopec is confirmed by finds including a 2.5 m deep v-shaped ditch. Nine substantial Classical Mad'arovce settlements (likely to have been occupied for multiple generations of the ca. 100 year Classical Mad'arovce period) and one cemetery are also known from Nitra City.[35] Allowing a notional population of 100 per open site to be contemporary to the occupation of Hradný Kopec (cf. population of Nitriansky Hrádok), the

31 Točík 1982

32 A. Točík pers. comm., Summer 1991

33 Cf. Bátora 1993

34 A. Točík pers. comm., Summer 1991

35 Točík 1993

Nitra City micro-region would have been inhabited by (ca.) 1100 individuals. Significantly, this population level is comparable to the socio-politcal transformation threshold from tribal societies integrated at a local group level (led by Big-men) to regional polity systems (led by chiefs).[36]

Settlements of the Early Bronze Age Únětice Culture in Bohemia

The Bohemian settlements of the Proto-Únětice Culture (Phase 1) consist primarily of isolated culture pits and homesteads, and suggest only small local populations. Modest settlement growth is then evidenced during Phases 2-3, for example at Blšany near Louny in Northwest Bohemia, where 11 settlement pits and one long house occur (Fig. 94). Extending 17.3 m in length and 6.1 m in width, the internal area of this domicile might have housed about ten individuals according to Narrol, or about two nuclear families, an interpretation which accords well with cemetery finds at the site.[37] A similar long house is known also at Konobrže in Northwest Bohemia, where the (ca.) 20 m long structure occurs with 18 graves from a unique burial mound,[38] although the greatest concentration of such long houses comes from Březno by Louny in Northwest Bohemia, where nine structures (all ca. 20 x 6 m) are found along with graves dating to Phases 2 and 3 of the Únětice sequence (a span of ca. 150 years). Assuming that each long house is occupied by (ca.) 12 individuals (after Narrol), an occupation by up to (ca.) 20-25 individuals over six generations may be conjectured (cf. Note 15).

The later (Phases 4-6) Únětice settlement archaeology of Bohemia consists of a relative wealth of evidence indicating a general prevalence of small villages.[39] The best evidence for Classical Únětice village settlement comes from Postoloprty in Northwest Bohemia, where 16 houses occur within the excavation area, where Soudský speculates (after the old short chronology) that 20 to 30 houses are contemporary.[40] This population level reconstruction seems too liberal in view of the new (long) chronology for the Únětice Culture, indicative of a span of more than 400

36 Cf. Johnson and Earle 1987, Sahlins 1968, Steward 1955

37 Pleinerová 1960

38 P. Čech of the Rescue Archaeology Unit (Ú.A.P.P.) at Most pers. comm., 1994. This house has been dated relatively through its spatial association with an adjacent grave tumulus. Two earlier Únětice long houses are also known from the Schöningen open-cast mine in Saxony (Dietmar-Wilfried 1987).

39 Cf. Smrž 1991, Dubský 1946 and Militký 1993

40 Coles and Harding 1979

calendar years.[41] Assuming a constant developmental rate for the Únětice Culture in its six phases, three generations for the occupation at Postoloprty can be reckoned. Thus one may infer that about 13 houses of a single-family type (ca. 40 m^2 each) are coeval, indicative of a village population of 65 individuals.[42] Although hill-top settlements are also known, evidence for actual fortifications is limited to the Late ("Věteřov") Phase (6).

Hill-fort settlement represents the final development of the Early Bronze Age in Bohemia.[43] These fortified sites are rather small (one to two hectares in extent) and are probably no more populous than open sites. A further development of note is the Late Únětice settlement of (upland) Southwest Bohemia, which produces the first evidence for occupation since the later Eneolithic abandonment.[44] Fortified sites predominate within this region, for example at Darmyšl-Chlum 35 km west of Plzeň. Slight occupation traces at this high (609 mamsl) place extend over seven hectares.[45] This reoccupation of areas marginal to agriculture around the Plzeň and České Budějovice basins of West and South Bohemia accords well with evidence for settlement growth in the lowland agricultural zone of the Czech and Slovak Republics.

Early Bronze Age burial rites and their reflection of social conditions east of the River Morava

Social implications of Nitra Culture funerary evidence will be briefly reviewed in this section. This Early Bronze Age culture (of Southeast Polish origin) exhibits attenuated traits of the Late Eneolithic. Osteologic evidence for raiding or warfare also occurs in Nitra Culture graves, after para-mortal impacts and embedded projectiles in inhumed skeletal material. With respect to the Nitra Culture funerary rite, this is clearly derivative from that of the Corded Ware, and is differentiated by gender. Weapons occur only in the graves of males, while both sexes share in the display of copper jewelry. This display is so common as to dampen expressed social differences based on such. In fact, a majority of graves bear bronze where grave robbery is not

41 Forenbauer 1993

42 Cross-cutting stratigraphic relationships occur one case at Postoloprty, where posts of House 6 cross House 10.

43 Smrž 1991

44 Bašta and Baštová 1989, Bašta et al. 1990

45 Bašta and Baštova 1989

problematic.[46] Thus, only limited earliest Bronze Age ranking is initially indicated in this zone.

Further features of the Nitra Culture burials include traces of para-mortal violence on skeletal material. Most persuasive of these cases is Grave 12 from Veselé (West Slovakia), where a stone arrow-head is embedded in the rib of a woman, a situation also observed in the case of a man (Grave 436) from the cemetery at Jelšovce in the Middle Nitra valley. Para-mortal impact on skeletons is also exhibited at the latter cemetery and that at Mýtna Nová Ves, most often in the form of bludgeoning or piercing marks to the skull.[47] Altogether, 36 graves (mostly male) exhibit traces of such para-mortal wounds, representing a wound and/or mortality rate of about 2%, somewhat less than that expected in ethnographic cases of intense tribal violence.[48] Also, the display of horse-riding prowess is made evident by means of special internment positions (the "frog-position" at Sal'a I /II and Jelšovce 444). Burial 444 at Jelšovce also produces a wooden chamber of the final period of the Nitra Culture, combined mortuary elements suggestive of an emergent tendency towards social ranking (Fig. 96).

Early Bronze Age burial rites and their reflection of social conditions west of the River Morava

Changing mortuary traditions inferred from Únětice funerary evidence include a trajectories of declining absolute grave wealth and increasing grave robbery. Secondary impacts on burials are also reflected in the robbery of skeletal elements (particularly crania) *per se*. Little direct evidence for para-mortal violence is indicated, although a discernible structural pattern of the evidence suggests that the acquisition of personal status or group cult are likely social foci for these activities.

In contrast to Late Eneolithic practice, the burial rites of females and males are uniform during the Únětice Culture of Bohemia and West Moravia.[49] Closer to the Morava River, a mixture of burial traditions is an exception to the rule, whereby the Proto-Únětice burials in Vyškov and Moravský Nová Ves express an affiliation with the Nitra Culture rite at this eastern limit of the

46 E.g. at Mýtna Nová Ves in the Middle Nitra Valley, about 80% of Nitra Culture graves contained artifacts of copper alloy (J. Bátora, pers. comm. 1994).

47 Bátora 1991

48 Cf. Haas 1990 (ed.)

49 A more conservative (Bell Beaker-like) tendency is notable in the Straubing Group in East Bavaria (cf. Hundt 1958).

Únětice Culture.[50] The later Únětice burial rite in Moravia also attests to a divergence from a normative, pan-regional burial orientation as an original north-south "internment rule" gives way to more localised orientation patterns. Únětice graves vary in wealth not only in relationship to inferred clinal differences in social status, but also (regressively) with phase. Earlier Únětice graves typically contain three to four vases, Classical graves only one or two, while Late Únětice graves contain but one or none. Extrapolating from this trend, the poverty of grave finds of the following Věteřov period is understandable.[51] Notably, the Late Únětice cemetery at Těšetice-Vinohrady (South Moravia) also provides substantiating data as to previous population estimates derived from settlement remains, where a reconstructed cemetery population of 60 to 70 individuals falls within the range of coeval village settlements.[52]

The phenomenon of burial in settlement pits is also suggestive of special rites, particularly where dislocation of articulated skeletal elements or para-mortal cutting or splitting of bone is demonstrated. Such practices are attested first during the period of the Classical Únětice Culture of Moravia, and more substantively in the terminal Early Bronze Age. For example, one pit of Late Únětice date from Blučina by Cezavy contained a mass grave of 12 individuals bearing traces of unhealed wounds caused by a bronze knife or dagger.[53] Among the 35 Únětice sites in Moravia containing human remains in settlement features, four also produce evidence of severed skulls (note that emergent variation in burial orientation might deter this activity in part). Similar finds of the Věteřov date include a mass grave of an old man, a young woman, six children and an ox in Feature 6 at Velké Pavlovice (Fig. 100).[54]

From Bohemia, an analogous mortuary pattern is observable at Tursko, Litoměřice and Blšany, where skulls are presented (often placed in bowls) in mass and individual ("ritual") inhumations.[55] The Blšany finds are also interesting in that the severed human skulls occur as "grave goods" alongside (ritual) Graves 10 and 37. Significantly, these (Phase 2/3) graves are

50 An unusual group of six cremation graves in a stone cairn-tumulus in the forest of Protivín in South Bohemia might also be reflective of southeastern influence (Dubský 1946).

51 S. Stuchlík, pers. comm. 1993, cf. Tihelka 1960, Lorencová et al. 1987, Stuchlík 1987, 1992a, Podborský 1993.

52 Lorencová et al. 1987

53 Salaš 1990a, 1990b, Jelínek 1990

54 Stuchlík 1992b

55 Jeleníková and Slama 1959, Pleinerová 1969

also the sole graves found with weapons (albeit in the form of flint arrow heads), and furthermore, Grave 37 with two arrows contained two skulls while Grave 10 contained one arrow and a single skull (do the these symbolise personal coups?). However, most of the 20 known Bohemian Únětice sites with human remains in settlement features belong to the late phase. The "social" component of these practices might bear upon the attainment of some kind of ideological status through slaying a foe within a context of tribal antipathy.[56]

Funerary culture of the Mad'arovce and Věteřov Groups

With the emergence of the Mad'arovce and Věteřov Groups, "living" modes of expression of social power such as chiefly houses and elaborately fortified centres are developed with a coeval decline in grave wealth, a trend which itself might be reflective of certain socio-political transforms. One transform to be inferred is the replacement of segmentary-competitive and relatively acephalous social modes by simple stratified ones. With this replacement, one vector of social competition is pacified, the acquisitive "Big-man" principle.[57] In the context of rampant grave robbery and fortification which occurs from the Carpathian Basin to Upper Silesia in the earlier Bronze Age period, these events probably reflect a wave of tribal warfare anticipating the foundation of regional polities which replace local Big-man groups. Only in the Late Věteřov-Early Tumulus (Reinecke B.A. A2/B1) period does an active expression of burial wealth return, for example at the Bronze Age mound cemetery at Borotice in South Moravia.

In Bohemia, this hypothetical set of circumstances appears later and to a lesser degree, while Beyond the northern limits of Bohemia, the principle of competitive display is hyper-developed in the cases of the Helmsdorf and Leubingen tumuli of Central Germany. These Saxon burials contain such juxtaposed elements as workman's tools and "chiefly" costume and weapon finds of gold and bronze, although the regional settlement pattern is indicative of only dispersed hamlet-based systems of the Early Bronze Age.[58]

56 Cf. Hutton 1969, Frazer 1922

57 Cf. Sahlins 1968

58 Cf. Billig 1958, Kristiansen 2000 and Childe 1945

Middle Bronze Age cultural sequence

The Middle Bronze Age Tumulus culture sequence (ca. 17/600 to 15/400 cal. BC) is represented by finds derived primarily from mound-covered graves. The range of ceramic forms includes handles jugs, footed-amphora (which will later develop into cylinder-necked amphora of the Urnfield Cultures), bowls and handled cups. Decorative attributes include applied "warts" ("Buckelkeramik"), incised concentric decoration, fluting (in the east) and stamped decoration (in the west). In Pannonia only, biconical vases appear in the Carpathian Tumulus Culture, and diffuse westward during the early part of the Late Bronze Age.[59]

Middle Bronze Age settlement

The Middle Bronze Age in the Carpathian Basin witnesses the abandonment or destruction of fortified centres of the Early Bronze Age.[60] Middle Bronze Age settlements lack thick settlement layers, although a limited continuity of occupation at some tel-type sites is traceable.[61] Domestic finds from Bezměrov in East Moravia are also suggestive of new house type with wall-trench construction, a type difficult to detect where there has been intensive erosion. Evidence from Bohemian sites is also lacking, where sunken features of any type never exceed three in number. The scarcity of settlement finds leads Neustupný to question the indicative value of this "hiatus" upon the supposition that the appearance of features at flat sites depends on the digging of pits deep-enough so as to survive subsequent erosion. However, the poverty of Tumulus finds need not result only from an arbitrary changes in "pit-digging" behaviours, but also due to differential visibility resulting from settlement dispersion.

The dependence of reduced representation of settlement features upon factors of relative feature dispersal becomes evident whenever extensively-excavated sites are considered, where-in settlement features of the same quality or type are preserved from different phases of the Bronze Age. For example, from Holubice near Brno in South Moravia, excavations revealed 23 midden pits spanning the period from the Classical Phase of the Únětice Culture (Reinecke Bronze Age

59 Gediga 1990

60 Spurný 1954 and Ožd'áni 1986

61 These settlement remains most often take the form of small groups of settlement pits, often filled with daub remains from domiciles no longer preserved (Ožd'áni 1986). Contra the general tendency towards "flat" settlement finds, an occupation layer 20 cm thick with "Pre-Lusatian" pottery was identified by Spurný (1954) at Hradisko near Kroměříž.

A2) until the Middle Tumulus Culture period (Reinecke Bronze Age C1).[62] During this 200-250 (cal.) year period, 21 pits of Únětice date are established, compared to only two pits of Tumulus date. A similar if later pattern emerges at Radonice in North Bohemia, where three sub-surface settlement features of Late Tumulus date represent the least-intensive phase of occupation, compared to the 16 sub-surface features established during the Early Knovíz occupation. This trend continues into the second Knovíz phase which produces 33 sub-surface features.[63] Assuming a constant relationship between sub-surface features and domiciles at Radonice (probably a ca. 4:1 ratio, see below), a twelve-fold local population increase over a 200-year period can be inferred. Analogous patterns of low-density Tumulus Culture finds emerge at trans-Bronze Age settlements at Horní Počaply near Mělník, Březno near Louny, Makov near Lístany and Bechyně near Tábor.[64]

A parallel settlement trajectory is demonstrable on a micro-regional level from the extensive salvage excavations of Smrž at Lužický potok in Northwest Bohemia. From this basin, a tabulation of all settlement pits from the Early (A) to Late (C) Bronze Age provides further evidence for a settlement minimum in the Middle (B) Bronze Age (cf. Figs. 5-7):

A. (Classical) Early Bronze Age: twelve settlement pits (zero graves) dug/250 years
B. Middle Bronze Age: three settlement pits (zero graves) dug/250 years
C. Late Bronze Age: 38 settlement pits (and six graves) dug/250 years

Southwest Bohemian cemeteries at Hájek (Fig. 101) and Svareč (Fig. 102) also provide a comparative demography to the sparsely attested Middle Bronze Age settlement record. These sites contain almost 100 mounds (prior to erosion), half of which belong to the Tumulus Culture

62 Geisler and Peška 1990

63 Bouzek et al. 1966

64 Settlement material of the middle stages (Reinecke B.A. B2-C1) of the Tumulus Culture is rarely encountered; although Horní Počaply near Mělník represents a rare exception to this rule (cf. Bouzek and Sklenář 1987). In general, most Tumulus Bronze Age settlement material belongs to either the Reinecke B.A. B1 or C2 sub-phases where sub-phases are definable. Thus excavations of 350 m^2 at Makov in Southwest Bohemia produces Tumulus Culture settlement material dating to the (Reinecke B.A. B1) Übergangshorizont in one sunken rectangular feature with loom-weights, as well as more numerous features with Early Urnfield material (Čujanová-Jílková 1972). Also in South Bohemia, salvage excavations at Bechyně near Tábor reveal 26 settlement features. Of these, two to three pits belong to the earlier (Reinecke B.A. B1) stage of the Oberpfalz Group of the Tumulus Culture, with the remaining 23 to 24 pits being attributable to the earliest (Modřany) phase of the Knovíz Culture (or Reinecke Bronze Age D; J. Militký pers. comm., 1993). Finally, the Tumulus occupation of site at Březno in North Bohemia is represented by a pair of sunken features, far less domestic evidence than that produced during the Early Bronze Age (nine long houses), or the 292 sub-surface features of the Knovíz settlement (Pleinerová 1972, Pleinerová and Hrala 1988)

proper.[65] Should a mound serve a family group for one generation period, a community of five families can be reconstructed based on pre-erosional conditions at these sites (Fig. 103). Isolated houses can also be preserved under burial mounds (at Vochov Tumulus 1, cf. Fig. 104).

The Late Bronze Age or "Urnfield" cultural sequence

The Late Bronze Age Urnfield period (ca. 15/400 to 800 cal. BC) represents the culmination of Bronze Age settlement expansion. This epoch also witnesses the rise of a new cremation rite in Central Europe, as well as extensive evidence for an enigmatic funerary cult in its establishment phase. The Urnfield cremation rite and set of sun and avian symbols itself first develops in the East Carpathian Basin, where these elements can be traced to the earlier Bronze Age.[66] A distinctive pottery assemblage is furthermore developed in tandem with this new rite, composed of urns, amphorae and biconical vases, whose diffusion can be viewed as a change in both ideal and material culture. First to receive this assemblage and rite *en masse* are groups of the "Middle Danubian" urnfields, a cultural zone occupying the lands near the Danube.

This culture has been divided into two main phases, an earlier "Velatice-Čaka Phase" (ca. 15/400-12/1100 cal. BC) and a later "Podolí Phase" (ca. 12/1100-800 cal. BC). The Velatice ceramic assemblage is characterised by well-burnished surface treatment, often embellished by ribbed fluting of a kind encountered in the Early Knovíz Culture in Bohemia. Initially, there are many similarities between the Early Velatice and Knovíz Cultures, for example, in the mutual appearance of the cylinder-necked and plain biconical vase. With the later "Podolí Phase" (Hallstatt B), forms undergo a gradual "smoothing" of profiles, while external graphite application also becomes prevalent on pottery vessels. Greater inter-regional differences in material culture become evident as cultural variegation proceeds into the later Urnfield period.

The somewhat distinctive Lusatian Culture occupies the entire boreal territorial zone from Northwest Slovakia to North-Central Moravia and North Bohemia. The Bronze Age Lusatian Culture is divided into two main phases, an earlier (Reinecke Bronze Age D to Hallstatt A) "Lusatian Phase" and a later (Hallstatt B) "Silesian" one, part of a now more variegated cultural grouping in the northern Urnfield Lusatian circle. Most conservative of the Urnfield cultures, archaic Middle Bronze Age attributes are well represented in the Lusatian Culture by "warty"

65 Franc 1906, Čujanová-Jílková 1970

66 Cf. Furmánek 1977a, 1977b

Buckelkeramik. Biconical vases also bear such "archaic traits" unlike their plain counterparts of Middle Danubia, while other attenuated forms include egg-shaped vessels. Reflecting a more Danubian tendency, the later Silesian Phase introduces graphite pottery.[67]

The "Knovíz Culture" constitutes the earlier Urnfield sequence in most regions of Bohemia. Ceramic forms developing include a characteristic storied vase, a tall cylinder-necked vase and an array of distinctive storage amphora, some with funnel necks. A biconical vase of a type plain in appearance (unlike its Lusatian counterpart) also appears. "Ribbed" decoration in fluted patterns like those seen in the Middle Danubian Urnfields is a leitmotif among decorative attributes. This the "Knovíz Phase" (Reinecke Bronze Age D to Hallstatt B1) of the Knovíz Culture (ca. 15/400 to 1200/1100 cal. BC), is further divided into six sub-phases on the basis of gradual formal development which ends in the Jenišovice (VI) horizon, particularly rich in bronze hoards.[68]

The "Štítary Phase"is a term applied to disjunctive and later Bohemian material of Hallstatt B2-3 date (ca. 1200/1100 to 800 cal. BC) and can be divided into three sub-phases. Štítary pottery is characterised by the introduction of graphite decoration as well as the application of a new form of surface roughening to storage vessels. The absence of the storied vase and cylinder-necked vase constitute further grounds for this chronological sub-division. Following the Knovíz (Milavče) period, a greater regional peculiarity in Southwest Bohemian material culture is evidenced in the Nynice Group. Although it bears graphitic pottery, the Nynice Group also produces pottery with trichrome red and black motifs against a yellow-painted background, attributes common to coeval cultures in East Bavaria. Special formal types of the Nynice Group include cattle-shaped vases which anticipate a renewed interest in such iconography to be observed in the Early Iron Age.[69]

67 Cups are a case in point respecting delayed Lusatian emulation of Danubian Urnfield material culture. High-handled cups of the Velatice Phase of the Middle Danubian Urnfields have no counterpart in the Lusatian Phase of the Lusatian Culture. Later, the Silesian (Hallstatt B) Lusatians adopt the high-handled cup of the Danubian tradition (pers. obs. in the depositoria of the Moravian Museum in Brno, 1994).

68 Kytlicová 1959

69 E.g. a horned animal vase from the epynomous Hallstatt B cemetery at Nynice, Southwest Bohemia (pers. obs. in the depositorium of the Plzeň Museum, 1991).

General Urnfield settlement pattern

The Urnfield epoch witnesses dramatic settlement growth in the Carpathian Basin and Central Europe. Due to discontinuities of burial rite in Central Europe, demographic calculations as to the rate of population increase cannot be made. In the Carpathian Basin, a continuity in the cremation rite dating from Middle Bronze Age times does allow for such an estimate, after Furmánek. Based on such analyses from 2,000 graves, Early Urnfield life spans are short (22 to 27 years inclusive of youthful mortality), and importantly, population increases threefold over the two centuries of the Middle to Late Bronze Age interface, (ca.) 17/1600 to 1400 cal. BC.[70] Isomorphically, an expansion of settlement can also be traced in South Moravia, where the network density of Early Urnfield settlement approaches one site per six km^2, while in Northwest Bohemia, a settlement network of one site per linear 2.5 km of drainage is achieved.[71]

Within the Lusatian zone, there is also a major expansion in the mortuary assemblage. Compared to Pre-Lusatian sites of up to 60 tumuli in Polish Silesia, the 1,260 graves of the Lusatian Culture at Moravičany in East Moravia are indicative of population growth. Upper Silesian urnfields are also extensive, with the Early Urnfield (Bronze Age III) period at Kietrz represented by 287 individuals in 161 graves (of a Late Bronze Age total exceeding 1,500).[72] Indeed, the Lusatian settlement in West Slovakia is suggestive of emphatic expansion, with periodic site totals increasing by 150% between its first and second stages as it extends its range from the inter-montane basins of the Tatras down into the Danubian Plain.[73] Similarly, in the Łiswarta micro-region in Little Poland, only sporadic Bronze Age finds are known until the emergence of the Lusatian Culture, when a surge of settlement is observed. By Hallstatt A times, Lusatian settlements are concentrated along small river courses only three to five km from one another. Expansion reaches its climax in Hallstatt B (Bronze Age V), when 162 find spots

70 Furmánek (pers. com.) estimates that the population of Southeastern Slovakia increased from ca. 20,000 to 60,000 by Kyjatice times, i.e. this region was inhabited by 120 local Kyjatice groups of minimal mating populations of 500. Affirmation of the significance of that number comes from demography of the South Slovakian urnfield at Šafárikovo, used by a population of ca. 600 individuals, based on excavations 600 m^2 in extent within a 5-6 hectare urnfield which produced 138 graves. Assuming that a representative sample was achieved, it seems likely that at least 10,000 individuals were buries at Šafárikovo throughout its history, a duration of 400 years maximum (Furmánek 1977a,b).

71 Salaš 1987, Bouzek et al. 1966

72 Gedl 1992b

73 Pavúk et al. n.d.

are recorded in this 315 km^2 area. These late sites lie as close as 0.5 km from each other.[74]

In the territory of West Slovakia, geographic oscillations of settlement zones are also well-documented (cf. Figs. 105-7).[75] The first (Velatice) phase is one of most extensive settlement, with up to four sites found per parish along the major and minor tributaries, (i.e.) a settlement net of about one site per 2.5 km of drainage, where a total of 168 sites are known (Fig. 105). These appear along all river valleys save the driest, low-lying bottoms between the Big and Little Danube. Importantly, the second (Early Podolí) phase of Urnfield occupation witnesses a dramatic contraction of Middle Danubian Urnfield sites from 168 to 27 (Fig. 106). During this same period, the number of Lusatian Culture sites increases by 150% in the upper reaches of the Váh and Nitra. Strikingly, the middle and lower reaches of these rivers are abandoned at this time, when Middle Danubian settlement has shifted to the Ipel and the White Carpathians respectively. Also, the czernozem soils favoured since the Early Bronze Age are abandoned for the para-brown earths with better moisture retention in areas of higher orographic precipitation (note then the Lusatian cultivation of drought-resistant spelt wheat). Analogous tendencies are also observable in the remnant of Middle Danubian settlement, where inundation areas of rivers are also exploited closer to the Danube. During the Late Podolí period (Fig. 107), a reoccupation of the Middle Váh and Nitra by spelt-growers of the Silesian Phase of the Lusatian Culture is observed, this being the time of their most-expansive settlement. A partial return to the black-earths can also be detected in this pattern, although unlike the Lusatian, sites of the Middle Danubian cultures remain limited to their prior cells. It is likely that these oscillations in Late Bronze Age agricultural settlement are modulated by conditions of periodic moisture stress.

Demography of settlement and special mortuary sites of the Velatice Phase in Moravia

The Velatice settlement of South and Central Moravia is known from at least 215 sites, of which at least half are settlements in the strict sense. Most excavations of these have been limited.[76] An exception to this rule is the village site at Lovčičky in South Moravia, where an area of 1.3 hectares was uncovered (within a four hectare site), producing remains of 48 houses

74 Gedl 1992a. A parallel phenomenon is also observable on the Glubczyce Plateau in neighbouring Upper Silesia, where in an area 30-40 km in diameter there are known 112 sites of the Lusatian Culture, including 45 cemeteries (Müller-Karpe 1980).

75 Pavúk et al. n.d., cf. Romsauer and Veliačik 1987

76 Salaš 1987a, 1987b

(Fig. 108). Domiciles are of variable construction, of which post-houses with planked and wattle-and-daub walls predominate. Some structures appear to be of an auxiliary sort, although most are of a domestic conception and enclose areas of up to 45 m^2. Significantly, a single house of large dimensions (20 x 6 m, Fig. 109) is suggestive of some communal function, such as the residence of a local head-man. A long post-built structure of multiple segments is also known (is this a compound household?). In addition, there are recovered (ca.) 200 sunken features of Early Velatice date, including a village well and storage pits containing (1-3) dis-articulated human skulls.[77] Ceramic finds indicate an occupation of four to six generations only.[78] Assuming then a maximum duration of occupation, a minimum population within the excavated area would average 40 individuals. Inclusive of the remainder of the un-investigated part of the site, a minimum number of villagers must have approximated 120.

Special cultic functions of Early Velatice date are also suggested in finds at Blučina-Cezavy, a site of some 17 hectares (at 250 mamsl) dating to the Reinecke Bronze Age C2/D, or "establishment phase" of the Middle Danubian Urnfield Culture, a duration of two to three human generations (cf. Fig. 110).[79] However, many events transpired within this relatively short period (ca. 1300-1250/25 cal. BC), including the deposition of at least 18 bronze hoards and the inhumation of at least 208 individuals (plus six recent finds) according to "a-ritual" rites within the secondary fills of an abandoned ditch of an earlier Věteřov occupation.

Early Urnfield occupation evidence in the strict sense is present at Blučina (about half a dozen features), but not so impressive as to account for the magnitude of mortuary activity, burials whose total is estimated to range between 1,500 and 2,500 individuals after Neustupný (assuming that the excavated 7% of the burial ditch is representative of the remainder). This estimate would indicate that about 20-50 individuals are interred each year.[80] What is also curious is the peculiar "method" of burial of this mass, which seems less-than-tranquil, for the 214 "M.N.I.'s" present in the excavated sections are represented by internments *en masse*, dislocated human limb articulations, severed skulls, articulated burials without skulls, burial postures suggestive of the binding of limbs prior to death and sacrificial episodes.

Specific examples of the above abound. For example, from the 1985 excavations come finds

77 Říhovský 1966a

78 Podborský 1993

79 Salaš 1990b

80 Neustupný 1983

in a rock-strewn area of six m^2, where under and amongst a floor strewn with stones were found mixed animal and human bone remains. The latter include a child skeleton whose rib-cage is pierced by a bronze dagger. An adult male also lay in this area, with his abdomen pressed between two boulders. The top part of the adult victim's cranium and his articulated arms and legs lay at a distance from his mutilated body.[81]

The earlier (1950's) excavations by Tihelka also yield evidence of similar practices. For example, Burial 33 produces a female skeleton with a bronze razor by her neck lying aside an inhumed male, her hand on the latter's pelvis (perhaps a fertility rite of the masculine aspect?). An analogous situation is found in Burial 43, where a child touches its mother (?) in the same place (again, perhaps a fertility rite, this time of the feminine aspect?). Detached crania are abundant, for example in Burial 40. Victims may also have been buried alive, in view of the "strange" situation in Burial 44, where "the male skeleton was...covered under boulders...the toe phalanges were stretched as if the individual had tried to get a firm footing on the boulder...the right arm was leaned against a stone (to provide leverage, and)...gave the impression of a struggling man".[82] It seems impossible then that this quality of burial evidence reflects mere secondary internments or non-violent episodes, although principally, the scale of the mortuary cult (1500-2500) at Blučina is most impressive. The attainment of such an assemblage of this quality cannot have been within the scope of a local group, rather the direction of these acts by a regional polity is indicated.

Settlements of the Lusatian Culture in Moravia

Limited settlement evidence of the Lusatian cultural zone north of Danubia is now reviewed. Although lowland settlements are common finds for the Lusatian Culture in North Moravia, few actual house plans are known, with most finds consisting of clusters of the ubiquitous storage pit.[83] An exception to this rule is the site of Předévsim in (Moravian) Silesia, where a central house (5 x 3.5 m) is surrounded by auxiliary structures and settlement pits.[84] More extensively excavated settlements of the Lusatian Culture in Southern Poland are suggestive of village

81 Salaš 1990b

82 Tihelka 1969

83 Dohnal 1977

84 Pers. obs. at the Regional Museum in Olomouc, 1994

occupations of (ca.) 50-100 inhabitants, and it seems likely that Moravian Lusatian sites attain the same population level.[85] Systematic excavations of Lusatian hill-forts in Moravia are also lacking. Three sections from Holý Kopec near Uherské Hradiště represent much of the published evidence, where Hallstatt B occupation extends along a ridge 700 m long and 100 m wide. Traces of stone-and earth fortifications and limited settlement evidence occur within.[86]

Danubian-Lusatian boundary sites of the Urnfield establishment phase

Velim in east Central Bohemia represents an early fortified site with Lusatian Culture finds on the Knovíz cultural boundary. This site on a gentle height near Kolín has produced an array of establishment phase finds, including four hoards of golden spiral wire ornaments. The original excavations by F. Dvořák before the last world war yielded evidence of the destruction of the early phase of settlement following an assault on the site's defenses.[87] Dvořák detected mass burning in carbonised structural remains, within which the occupation layer was strewn with masses of human bone and bi-lobate arrows. Subsequent excavations have produced evidence of destruction in the remains of sequential (super-imposed) timber and (later) stone fortification walls and ditches. The area of the later (Reinecke D?) outer fortification also contains earlier (Reinecke C2) mass deposits of para-mortally-impacted human bone, including an internment of 18 partially dismembered individuals mixed with animal bone on a surface paved with pebbles (Feature 23). Recent excavations by Hrala and Harding have also detected mass funerary features of an "enigmatic" character (Fig. 111). These finds, coeval with the transition from the Tumulus to the Urnfield Bronze Age, are coeval with analog sites at Blučina and Přítluky in South Moravia, and attest to a wider prevalence of the mortuary cult evident at the latter sites.

Settlement populations of the Knovíz Phase in Bohemia

The Knovíz settlement of North Bohemia is typified by a dense net of village sites along major and minor tributary valleys, where such sites found at intervals of 2.5 kms. Periodically (at ca. 20 km intervals), these are augmented by fortified village sites. North Bohemian settlement

85 Bukowski 1978

86 Nekvasil 1990

87 Hrala et al. 1990, 1992. Notes of these earlier finds at Velim were lost during the Second World War.

archaeology attests to villages occupied for the entire sequence (e.g. Velemyšleves) and shorter-lived hamlets such as Liptice (cf. Fig. 112).[88] The site Březno in the Middle Ohře valley will serve as an example of a modal intermediate type of settlement.

The Urnfield occupation at Březno by Louny dates to the earlier half of the Knovíz period, for a span of 200 to 250 years. From the 22,165 pottery sherds recovered from the excavation of 292 cultural pits, it is apparent that the settlement reaches its height during the second sub-phase of the Knovíz Culture, a period of some three generations. Of the 292 features recovered, 204 can be assigned to a particular phase; and of these, 137 date to the second Knovíz sub-phase. On a proportional basis, 60 of the remaining 88 pits might be assigned to the second phase as well, producing a sub-total of 197 settlement pits dug during three generations of occupation in the second sub-phase. Assuming (after Lovčičky) that four such pits correspond to an above-ground structure, and that one third of such structures are coeval (i.e., occupied for a single human generation), a quotient of 16 to 17 households might have been present at the height of occupation of Březno within the excavated area alone. Finally, given the fact that surface finds reflect a total occupation area of 3.5 hectares, of which 2.5 hectares has been excavated, one might extrapolate a final product of 23 contemporary households at Březno at the height of occupation, for an estimated population of (ca.) 115 villagers.[89] Notably recalling finds from Velim, Blučina and Lovčičky are deposits of human skeletal material in 13 settlement pits of earlier Knovíz date.

The hill-fort settlement of the Knovíz Culture in Northwest Bohemia has been analysed by Smrž.[90] Excavation of the interiors of these sites is limited, as is an understanding of the systematic relationship of hill-fort to lowland settlement, although in their geographic context, Knovíz hill-forts might be characterised by their relatively low elevations (ca. 400 m. a.m.s.l.) when compared to (unfortified) hill-top occupations (often over 650 mamsl). Hill-forts proper are most often fortified by means of an outer ditch and inner wall, the latter is often composed of stones as at Černovice and Mukov, sites fortified in the Modřany (establishment) Phase of the Knovíz Culture. The extent of intensive occupation varies, although six to seven hectares is typical. Notionally, hill-fort populations may be double that of the 3.5 hectare village of Březno,

88 Cf. also Friedrich 1954, Bouzek et al. 1966 and Smrž 1987a, 1987b

89 This estimate falls within the range of 110-140 inhabitants predicted by Hrala and Pleinerová (1988).

90 See Smrž 1995

for a hypothetical population of (ca.) 230 inhabitants.

Late Urnfield settlement

The final two to three centuries of the Urnfield epoch (Hallstatt B) in the Czech and Slovak Republics are represented by finds of four main cultures: a) the Podolí Phase of the Middle Danubian Urnfields, b) the Silesian Phase of the Lusatian Culture in West Slovakia, North Moravia and North Bohemia, c) the Štítary Phase of the Knovíz Culture in East, Central and Northwest Bohemia and d) the disjunctive Nynice Group in Southwest Bohemia.

Late Urnfield hill-fort settlement of Moravia

Among Podolí Culture settlements in Moravia, only the hill-fort at Brno-Obřany has seen extensive excavation, where a total of 300 features (rectangular sunken huts, culture pits and storage pits proper) have been discovered within an indeterminate excavation area. The site is enclosed by massive wall and ditch which achieves a 7 m height in places, (i.e.) of both monumental and defensive effect (Fig. 115).[91] Its circuit encloses 24 hectares of the main settlement (entered *via* an elaborate gateway), while a small area atop the adjoining heights ("Skály") forms a fortified "keep". Features within the main site are comprised primarily of "sunken huts", which might actually serve as work stations; although Adámek proposes their use as domiciles. A find of a post structure (Feature 72) surrounded by daub with impressions of "full, round wood" throws doubt onto this latter proposal, since its dimensions (8.4 x 6.8 m) are far more commodious than most of the "pit houses".[92]

Late Urnfield hill-top settlement of Bohemia

Comparatively, the excavation of the Early Štítary Phase hill-top settlement at Mikulovice by Kadaň in Northwest Bohemia also represents the only investigation of its kind.[93] Situated on a

91 J. Merta of the Brno Technical Museum, pers. comm. and site tour, Winter 1995.

92 Finds from Feature 37 are also suggest aspects of an iron workshop, whence a collection of graphite-lined smelting equipment was retrieved. The iron weapon finds from Grave 169 at the Brno-Obřany cemetery suggests that the emerging local iron-working tradition served the "elite" warrior lineage rather than the common farmer (Adámek 1961).

93 Smrž and Mladý 1979

height (of 403 mamsl) some 70 to 90 m above the surrounding terrain, this defensible position produces no evidence for artificial defenses, although it seems to regionally fulfill a quasi-hill-fort role. Erosion down the gentler northern slope has been extensive, where 11 "sunken-huts" and isolated post-holes occur in test trenches and small excavation blocks which cover 3% of the settlement area. Finds of a two-piece mould for an arrow head and a crucible in Feature 3/72, a whet-stone from Feature 1/72 and a loom weight and spindle-whorl from Feature 1/74 suggest that these sunken features serve as stations for bronze-casting and textile-weaving rather than huts. Using then a sub-surface feature to post-house constant of 2:1 to be derived for the Hallstatt B-D/La Téne A periods (see Kuřim ratio, Chapter 11), between five and six houses spanning an occupation of about three to four generations can be reconstructed at Mikulovice within the limited excavated area. Following from these grounds, a modal, total site population of 200 to 330 can be estimated.[94]

At lowland villages, a settlement continuity to the Štítary Phase is common, although sub-rectangular sunken features constitute a new element at such Late Urnfield settlements.[95] Of Štítary storage pits, these are less numerous, but more volumous. Knovíz pits typically contain a volume of (ca.) 1200 dm^3, while their Štítary counterparts typically contain (ca.) 2,000 dm^3.

Additionally, fortified sites of the culturally disjunctive Nynice Group are documented in upland Southwest Bohemia, where they appear at 12 to 16 km intervals, suggestive of "hill-tribal areas" of 70-200 km^2 (cf. Fig. 114). Sites of this class produce evidence for fortification walls of earth (reinforced by stone) along with intensive occupational debris.[96] Unenclosed Nynice Group sites are poorly documented.

Reflection of rank in Urnfield cemeteries

A disparity of funerary wealth is evident during the Late Bronze Age to an extent indicative of social ranking, although empirical limits are significant, in that ranking is most actively symbolised at the very beginning and very end of the Urnfield sequence in Central Europe.

The cremation cemetery sites which give the Urnfield Bronze Age its name are formed of a

94 Smrž and Mladý (1979) do not consider the unexcavated ratio in their occupational demographic reconstruction of two to three coeval family groups at Mikulovice.

95 Bouzek et al. 1966, cf. also Turková and Kuna's (1987) analysis of the micro-structure of settlement at the sites of Radonice and Roztoky of the Knovíz and Štítary Phases respectively.

96 Šaldová 1981

diverse range of particularistic burial practices which are not culture-specific, but rather reflective of more local traditions. Most burials of this period are of the cremation type, a rite effected in-situ, within the burial pit, or without. Cremation urns or bowls may also contain these remains, or are placed aside the cremation. Burial mounds are sometimes encountered, particularly in South Bohemia (where less-intensive agricultural practices have failed to obliterate such evidence), however, this tendency merely reflects an attenuated practice of the Middle Bronze Age (most tumuli date to the early part of the Urnfield sequence).[97]

The phenomenon of rich burials also seems to be most pervasive during the establishment phase of the Urnfield cultures (i.e. Reinecke Bronze Age C2/D to Hallstatt A1). Furthermore, rich mound graves of the earlier (Reinecke Bronze Age C2/D) period occur mostly in the east (e.g. at Velké Hosterády I and III in South Moravia and at Očkov in West Slovakia),[98] while those of the later (Reinecke Bronze Age D/Hallstatt A1) period occur mostly in the west (e.g. at Milavče in South and Žatec I in Northwest Bohemia).[99] Significantly, few traces of a warrior class are evident in the (socially more segmentary?) Lusatian Culture area until the (terminal) Hallstatt B3 period. This same "disintegration phase" of rich burials also becomes evident at the very end of the Danubian Bronze Age, for example in the iron spear, sword and ax equipped Grave 169 at Brno-Obřany (Fig. 116).[100]

Amongst the common run of urnfields, relative poverty prevails everywhere. In Bohemia, the relative frequency of weapon burials drops to nil at many cemeteries. The largest-known cemetery of the Knovíz Culture at Křepenice in Central Bohemia produced little more than odd pins of bronze and pottery urns. Similarly, at Klentnice in South Moravia, graves average one bronze (usually a pin) per grave, while at Podolí by Brno, only one grave in four contained such

97 Cf. Franc (1906), Hralová (1987) for Southwest Bohemia, Smrž (1975) for Northwest Bohemia and Gedl (1992) for Polish Silesia.

98 Velké Hosterády contains two graves of particular wealth (Mounds I and III) equipped with swords, daggers, needles, razors and multiple pottery vessels of terminal Tumulus Culture or earliest Urnfield date (Říhovský 1982a). Much richer is the dual-chamber tumulus at Očkov dating to the beginning of Reinecke Bronze Age D. Remains of over 100 pottery vessels were discovered within the disturbed (robbed?) chambers at Očkov, in addition to remains of golden wire ornament (part of a burial costume?), as well as a sword, spears, a knife, needles and five bronze vessels (Paulík 1962).

99 Cf. Preidel and Wurdinger 1928, Kytlicová 1959, 1992. Compare also Grave I from München-Grünwald, dating to the Hallstatt A1 stage, where along with its extensive assemblage of bronze costume-ornaments, finds of two needles are suggestive of a female internment. Twenty-four bracelets are interred with this Early Urnfield cremation in a large bronze bowl (Müller-Karpe 1957).

100 Cf. Dvořák 1938, Stegmann-Rajtár 1992. This Hallstatt B3 "disintegration phase" is most emphatically represented by the Seddin Tumulus near Prignitz. Averaging 126 m in diameter, this 30,000 cubic metre mound required 150 man-years of labour to build. The central chamber (Vitrine 21) was built of stone and contained the burial of an adult male and a marten (totem?). Bronze and iron grave goods from Vitrine 21 are contained in two skeuomorphic urns. A formal type normally made in clay was made of silver, while a type normally made of bronze was made of gold.

types.[101] In terms of wealth, the burials of the Lusatian Culture in Moravia represent the nadir of the Urnfield period, where-in large cemeteries at Sehradice and Vlachovice produce practically no bronze, which is found as small items (usually pins) in only 1.5% and 5.4% of graves respectively.[102] Of the urnfields of the Lusatian Culture then, their only impressive feature is mass. In view of the fact that the largest cemetery of the Knovíz Culture registers only 110 graves, while the largest Velatice-Podolí urnfield yields 228 (at Domanyslice), the Lusatian cemeteries at Vlachovice (365 graves), Sehradice (471 graves) and Moravičany (1,183 graves) are funerary collections of a higher order. Possibly, these differences in scale may reflect the use of individual cemeteries by multiple settlements in the Lusatian Culture area, and thus different cultural norms *vis a vis* Danubia. A relative blanket of mortuary poverty in the Lusatian zone also reflects a lower level of access to networks of copper, tin and bronze-alloy exchange which is suggestive of a certain social distance from Danubian Urnfield system.

Danubian funerary cult and society in the Urnfield period

Special mortuary finds of the establishment phase of the Urnfield epoch also warrant further speculation as to the adjudication of the funerary cult at Velim, Blučina and elsewhere in Danubia. The scale of inhumations at Blučina in particular is indicative of the domain of a regional polity rather than that of a local group.[103] After osteological and material evidence, the basis of this chiefly authority might have arisen in a context of increasing tribal violence.

What is interesting here is the possible means of ideological justification of this new Urnfield social order. It is perhaps the "guarantee" of material well-being through practices of fertility rites, rites whose right had devolved into certain lineages through the expression of prowess (e.g. warfare) and the coincidence of the reconstructed period of highly improved agro-climate. The diffusion of sun and avian symbols (cf. the use of observations of avian movements as weather vanes in the Archaic Aegean) with the urnfields may be significant in this respect, as the beneficent effects of a greatly improved agro-climate might have been ascribed to what-ever tribal lineages are prominent prior to the inception of the Urnfield system.

In this tribal context, the act of promotion of systems of rank may reflect a maladaptive

101 Cf. Hrala 1973 and Podborský 1970

102 Cf. Harding 1987

103 Cf. Kosse 1990, 1994 and Johnson and Earle 1987

adjustment on the part of the individual farmer (potentially misguided by an ideologically-limited psycho-cultural filter), although societies so-integrated might have a political advantage in ideologically-motivated tribal warfare. Thus an adaptive convergence of neighbouring tribes towards more integrated political units might take place until a mosaic of small regional polities is established across much of Central Europe, irrespective of the actual benefits conferred by this system to the mass of the farming population. In the broader sense, the concept of ideology limiting adaptation in early farming communities would seem to be a valid one, as actual perceptions of cause and reaction to effect with with respect to environmental stimuli in a cultural system may be profoundly affected or channeled by ideological factors.

With a return to more peaceful conditions consequent upon the establishment of the Urnfield system, the now inter-regionally integrated Urnfield chiefs might still participate in less lethal, "ritualised" and socially supportive combative roles, employing a demonstrably impractical Urnfield panoply.[104] Thus this set of bronze arms and armour is maintained with little functional change for more than 500 years (ca. 1300-800 cal. BC). The necessity of such arms is a result then of purely internal and "involutionary" social needs rather than a developmental and "evolutionary" response to an external threat (as per inter-community raiding or warfare). Other examples of modes of combat as determined by social reification of a sub-group rather than defense for the society as a whole might be readily drawn from Antiquity onwards.

The influence of this innovative cult on changes in funerary rite might be reflected in a complementary ideological reaction by the farmer who contrived *via* cremation to protect his "spiritual substance" from "a-ritual" inhumation, (i.e.) a kind of preventative homoeopathetic magic. The incidence of para-mortally impacted or mutilated skeletal material (more than 90% male) in settlement pits is significant in this respect. These unusual "rites" are documented at 80 Knovíz sites in Bohemia (including villages as well as cult-centres like Velim), in addition to Velatice cult-centres such as Blučina and village sites such as Lovčičky in Moravia.[105]

Evolution of Bronze Age arable agriculture

Macro-botanical finds of cultivars of Bronze Age date in the Czech and Slovak Republic are now reviewed. The botanical range of Early Bronze Age agriculture is comprised of an arable

104 Schauer 1990, cf. Coles 1962

105 Settlement pit finds of isolated skulls are almost exclusively from male graves (Bouzek and Koutecký 1980).

dyad of emmer wheat and hulled six-row barley which predominates in both the Czech and Slovak Republics, probably as separate field crops.[106] However, steno-edaphic but highly productive bread wheat (*Triticum aestivo-compactum*) becomes an important crop for the first time, appearing at ten (late) sites in the Czech Republic (e.g. at Holubice, where it appears in two features) and six (early and late) sites in the Slovak Republics (e.g. at Nitriansky Hrádok, where it appears in ten features).[107] Tempír believes that this advanced wheat forms a separate crop during this Classical period of the Early Bronze Age, although Hajnalová expresses certain reservations on this point. Einkorn certainly appears as only a minor admixture to the wheat crop, while traces of morphologically domesticated rye (*Secale cerealia*) make their first appearance at the end of the Early Bronze Age (e.g. in Late Únětice contexts at Blučina, in Mad'arovce contexts at Nitriansky Hrádok and in Otomani contexts at Spišský Štvrtok).[108] More problematical are Tumulus Bronze Age finds of millet at the site of Moravský Krumlov, where it is found admixed with rye. In view of the shorter growing seasons expecting during the cold agro-climates of the Loebben Oscillation, the properties of millet might have been first appreciated in Middle Bronze Age times.[109]

Pulses also make sporadic appearances during the earlier Bronze Age, for example in finds of *Vicia faba* at Blučina.[110] The latter Mediterranean crop (a.k.a. horse bean) becomes more widespread with the Urnfield period. The Urnfield age also brings a significant expansion to the range of grain crops, including the first substantial finds of millet at Prague-Černošice.[111] The short growing season of millet (60 to 90 days) as well as its general hardiness with regard to soil conditions would have encouraged its use by Late Bronze Age farmers as a secondary crop as part as a risk-minimisation strategy of arable production.[112] Its presence is also widely

106 Wasylikowa et al. 1991, Hajnalová 1990, 1993

107 Geisler and Peška 1990 Hajnalová 1989

108 Salaš 1990a, Hajnalová 1989, 1993

109 Hrubý 1950

110 Salaš 1990a

111 Harding 1989

112 Zohary and Hopf 1988

reported at (80% of) sampled sites of the (Late Bronze Age) Lusatian Culture in Poland.[113]

At sites of the Lusatian Culture, hexaploid spelt wheat (*Triticum spelta*) also becomes important, appearing as a dominant crop at 60% of sampled sites in West Slovakia. The resistance of this cultigen to drought is certainly an agent in the relative success of Lusatian settlement in West Slovakia, where substantial finds from Middle Danubian sites are lacking.[114] Rather than reflecting a deliberate act of selection, a genetic study of spelt is indicative of its accidental origins as a hybrid of tetraploid emmer wheat and the wild diploid grass *Aegilops squarrosa*.[115] Only in the Urnfield period are the edaphic qualities of the hexaploid recognised.

Altogether, innovations in the Late Bronze Age arable regime reflect an increased consciousness of the need to exploit crops capable of thriving under more marginal growing conditions. Such marginal growing conditions may include the incorporation of poorer soils to arable cultivation in the case of millet, while the overall character of the Urnfield botanical assemblage suggests that new crops are not related to wetter (minimal) agro-climates, as the case of spelt demonstrates. This selective process might have been encouraged by the higher population densities achieved in the Urnfield epoch, densities which reduced the tolerance for even partial crop failure. The net result of these changes may be characterised as a further extensification and risk-reduction of agriculture rather than its intensification.

Evolution of Bronze Age pastoral production

Of the pastoral economy, few changes are evidenced during the Bronze Age, although evidence for horse domestication is quite conclusive. Cattle (still) predominate among the domesticates.[116] A particular ritual importance of cattle is evident at earlier Bronze Age sites such as Úherský Brod in East Moravia, where a carcass is inhumed with some care amongst an

113 Wasylikowa et al. 1991. Note then the transference of the Indo-European "barley" term to millet ("proso") in the Slavonic languages generally *vis a vis* the theory of the "Slavonic affiliation" of Lusatian Culture communities (cf. Clarke 1968) and the extreme glotto-chronological conservatism of agricultural terminology (cf. Markey 1989).

114 E. Hajnalová pers. comm., Summer 1991. Minor admixtures of spelt wheat are known from the Velatice site of Moravany nad Váhom, in a region of mixed Danubian and Lusatian settlement in the West Slovakian uplands. Minor admixtures of spelt wheat are known from Neolithic times, although pure finds in Lusatian contexts signify the cultural act of recognition of its edaphic qualities which is considered as conceptually important in this context (cf. Hajnalová 1990, 1993).

115 Zohary and Hopf 1988

116 Bőkönyi 1974

array of other faunal and ceramic offerings.[117] Later, the faunal assemblage of Velatice Culture date at Lovčičky in South Moravia may serve as a model of the Urnfield Bronze Age pastoral economy. Here cattle comprised 35% of the total assemblage of bone fragments, followed by sheep/goat (21%), domestic pig (19%), dog (9.3%), horse (5%) and hen (0.04%). Bone fragments of wild animals comprised only 5.1% of this assemblage, of which interesting aspects include hare (3.2%) and deer (1.3%), hare being in contrast to deer a creature of pasture and steppe.[118]

Preserved woolen textiles of Bronze Age date are known from Thuringia and Denmark.[119] The production of woolen over flaxen textiles may have been encouraged by the lower labour requirement for the preparation of the constituent fibres of the former.[120] It is likely that communities throughout Central Europe used sheep for wool production in this epoch.

Finally, the appearance of horse at many Bronze Age sites in Central Europe is well-documented. The common appearance of antler cheek-pieces from both Early and Late Bronze Age sites also attests to the use of the horse as a riding animal, first at the fortified settlements of the earlier Bronze Age, and then in both fortified and open villages of the Urnfield Cultures. The introduction of larger breeds of equids from the North Pontic region is accompanied by other "steppic" cultural influences, particularly the "frog-position" of supine inhumation found in Nitra Culture warrior graves.[121] This is the position the legs would take to secure oneself when riding without stirrups (Fig. 96). The frequency of equid finds at Carpathian Basin sites might reflect more-open conditions on the Hungarian Plain, although isolated finds also appear in Bohemian (Knovíz) contexts, for example, the Mound 3 horse burial (with harness) at Žatec in the Middle Ohře Valley.[122] Artistic portrayals of the horse-drawn chariot are also known from the end of the Early Bronze Age, including one engraved on a vase of the Suciu de Sus Culture at Velké Raškovce in East Slovakia. Also from the Early Bronze Age in East Slovakia comes a unique spoked wheel on a bronze pendant crowned with horns from the Hatvan Culture

117 Gimbutas 1965

118 Podborský 1993

119 Cf. Feustel 1958, Coles and Harding 1979 and Ryder 1983, 1969.

120 Ryder 1969, 1983

121 Cf. Bőkönyi 1987 and Bátora 1990

122 Preidel and Wurdinger 1928. Further ritual horse burials have since come to light in the territory of Lusatia, including an equid with offerings of swine at Altdöbern 16 near Cottbus (Böhnisch 1986).

occupation at Včelínce, possibly representing a chariot-riding deity (cf. Helios).[123]

Population dynamics and the evolution of Bronze Age settlement

The general Bronze Age population trajectory may be characterised as exhibiting a dual-peaked pattern. A first period witnesses a steady growth of population densities during the Early Bronze Age, culminating in a final spurt of settlement population agglomeration during the Classical stage (cf. Fig. 5). This period begins with the settlement of small local groups, sometimes centered on a large (central) cemetery in the Nitra Culture, or producing small settlement-specific cemeteries in the Early Únětice Culture. Local farming communities coalesce into larger households only during Phases 2-3 of the Únětice Culture. In the later part of the Early Bronze Age, larger, still-more archaeologically visible sites are formed.

Higher population levels achieved by the Classical Early Bronze peoples are anticipated by more pervasive tribal violence and fortification of "central" village sites. In this respect, the agglomeration of population in Pannonia can be understood as reflecting both demographic increase and increased social needs of defense. The possibility that local groups of Pannonia form into regional polities of (ca.) 1,000 inhabitants should as be considered (at least) as a strong working hypothesis (Fig. 99).[124]

An intervening relapse of this emergent regional polity system at the beginning of the Middle Bronze Age might have come about due to the inability of the primitive systems of agriculture then in place to support greater population densities in times of ecological stress (i.e., during agro-climatic minima). Such ecological stress would have come about through the lowering of agricultural *K* capacities of respective community areas with the onset of the Middle Bronze Age Loebben Oscillation (minimum). Once lower population levels are reached early in the Tumulus Bronze Age, evidence for tribal violence also becomes scarce (cf. Figs. 6 and 8). A return to "quasi-Early Únětice" conditions might be imagined, with the formation of households in hamlets around central tumulus cemeteries, as no evidence for true village settlement can be detected. This settlement condition endures for a period of about two centuries (end of Reinecke Bronze Age B1 to C2), until a population rise anticipating Urnfield developments is detectable at the end of this sequence (Reinecke B.A. C2/D).

123 Furmánek and Marková 1992

124 Cf. Steward 1955, Johnson and Earle 1987, Kosse 1990, 1994

A second period of population growth comes with the establishment of the Urnfield cultures, when an initial "horizon" of tribal violence (Fig. 111) is followed by a far longer period of relative homeostasis. Although the general settlement net becomes relatively dense, it is likely that most villages never achieve concentrations of more than 125-50 inhabitants (at 2.5 km intervals, Figs. 108-110). The implication in population biological terms is that adequate mating networks could be achieved within a 10 to 15 km section of a river valley in places of prime farmland (cf. Fig. 7). This "150 threshold" is also the observed level at which village settlement bifurcates in the absence of local (village-level) political control (see Chapter 2).[125]

In view of a tendency for tribal society to be more prone to endemic violence under higher population densities with closed, philopatric mating networks, regional control by established chiefs may engender more peaceful inter-regional socio-political relationships in the Late Bronze Age.[126] Ultimately, then a very high degree of settlement agglomeration is particularly evident at Hallstatt B hill-forts in the Danubian cultural zone. This settlement development may reflect upon the socio-economic adjudication and ideological legitimacy of leading lineages. As a sub-hypothesis, one might also propose that after centuries in power, such lineages may establish a system of conical clans which ranks lineages vertically within an inter-regional system of micro-regional polities. This hypothetical socio-political system seems to receive a renewed mortuary expression in chiefly burials at the very end of the Bronze Age (cf. Fig. 116 and Note 100).[127]

Distinctive to the Lusatian Culture is the long life of individual cemeteries. Hill-forts in this northern cultural zone become important only with the Silesian Phase (Hallstatt B) in Moravia and Bohemia, although these seem to be placed at the peripheries rather than centres of main settlement zones (Fig. 113). In West Slovakia, "buffer-zones" between Lusatian and Danubian settlement areas may also have reduced the defensive need for hill-forts in this upland region.

A comparison of reconstructed settlement and cemetery populations by period and region now follows (Table 10.1).

125 Cf. Kosse 1990 in particular, see also Sahlins 1968 et al.

126 Cf. Manson and Wrangham 1992, Sahlins 1968 and Hutton 1968

127 Cf. Sahlins 1968.

Table 10.1. Inhabitants per site for the Bronze Age in Bohemia, Moravia and Slovakia

Chronological Period and site aspect	*Bohemia*	*Moravia*	*S.W. Slovakia*
Nitra Culture settlements	n/a	ca. 5-10?	ca. 5-10?
Nitra Culture cemeteries	n/a	ca. 50-60	ca. 60-70
Early Únětice settlements	ca. 20-25	as per Bohemia?	n/a
Late Únětice settlements	ca. 65	ca. 70?	n/a
Late Únětice cemeteries	as per Moravia?	60-70	n/a
Věteřov-Mad'arovce hill-fort sites	n/a	as per Slovakia?	ca. 215
Věteřov-Mad'arovce village sites	n/a	ca. 100?	ca. 100?
Middle Bronze Age settlements	ca. 5-20	ca. 10- 20	as per Moravia?
Middle Bronze Age cemeteries	ca. 25	as per Bohemia?	as per Bohemia?
Early Urnfield hill-fort sites	ca. 200-250?	ca. 200-250?	ca. 200-250?
Early Urnfield village sites	ca. 115	ca. 120	as per Moravia?
Late Urnfield hill-fort sites	200-330 or more?	as per Bohemia?	as per Bohemia?

Populations of Urnfield regional polities

It remains to be established as to what scale of territory and population might comprise a hypothetical Urnfield regional polity. Direct empirical approaches along these lines have been initiated by Simon for the Urnfield settlement zone of present-day Thuringia (cf. Fig. 114). This study by Simon discern a two-tiered system of settlement cells in micro-regions of 60 (lowland) to 100 (upland) km^2 land-area, where central hill-forts form an upper tier.

After Wagner, a similar micro-regional patterning is apparent amongst the mass of settlement evidence in the Lower and Middle Unstrut valley west of Leipzig. This mass once more consists of a <u>mosaic</u> of concentrations of settlement finds along (ca.) 15 km sections of water-way, between which lay "buffer-zones" of up to five km. Progressively in the Urnfield sequence (Hallstatt B to Billendorf), these buffer zones are filled-up as later prehistoric settlement expands to a maximum limit which is not exceeded until the Early Middle Ages.[128]

Allowing Urnfield sites from the Unstrut radial community areas of two km each, a mosaic of micro-regional polity areas result which are similar (50-60 km^2) to that discerned in lowland Thuringia. A geographical appraisal of the network of hill-forts in Northwest Bohemia allows for similar reconstructions, while the Danubian pattern in lowland Moravia is also comparable, where-in up to three hill-forts are centred in site clusters of up to 180 km^2 land area, or 50 to 60 km^2 per hill-fort. Applying this geographic scale to well-investigated areas in Central Bohemia, the lowland environs of the Únětický potok near Roztoky is used to reconstruct a micro-regional demography for the Urnfield period (cf. Fig. 8). Extending some 50 km^2 in area as per the micro-regional entities of Simon and Wagner, the Roztoky micro-region has been ecologically circumscribed by Kuna into eleven community areas of prehistoric farmers.[129] Applying "modal village populations" to each of the settlements in these areas (Table 10.1), one obtains levels of 100-300 inhabitants per community. In other words, these <u>individual</u> community areas do not contain truly viable mating populations. Definitive evidence for a hill-fort within this 50 km^2 area is lacking, however the focal point of promontory settlement at the heights of Roztoky is proposed as a possible centre of a regional polity. Within this 50 km^2 area west of Roztoky, 21 Urnfield settlements are evident, of which an unknown quantity are coeval.

128 Cf. Wagner 1992 and Simon 1984. Independent of hill-fort loci, Berger (1984) also reconstructs cultural (tribal?) territories in the order of 100 km^2 in the uplands of Lower and Upper Franconia, based on evident differences in material culture (weapons, ceramics <u>and</u> personal ornaments) between Reinecke Bronze Age C and D.

129 Kuna and Slabina 1987, cf. Salaš 1987b and Smrž 1995

Should one assume after settlement archaeology and cemetery chronology that village sites on prime arable land endure for (ca.) 250 years during the Urnfield period, one can presume that at least ten Knovíz villages are concurrent in Úněticky potok region, non-inclusive of the focal site at Roztoky. Applying reconstructions of modal populations for individual "village" (generally) and "hill-fort" (at Roztoky) sites, a regional population of (ca.) 1,300 may be derived.

Higher ranking clans within such regional populations cannot have maintained exogamous lineages without recourse to inter-marriage with "lower" ranking clans, thus reducing vertical social cohesion; although such practices might have been the norm amongst more segmentary tribesmen in Lusatian Culture settlement zone, where central hill-forts are often lacking. In order to maintain vertical cohesion in the Danubian zone (where comprehensive evidence for social ranking is pervasive), the erection of extensive, inter-regional networks of exchange of marriage partners between leading lineages would become a population biological necessity.

Review of demographic reconstructions

Population reconstructions of individual Bronze Age settlement sites have been made on the basis of actual household finds as well as observed 4:1 ratios of settlement pits to domiciles until the Hallstatt B period. Pre-Hallstatt B reconstructions by both methods yield a considerable internal consistency. For example, Classical Únětice village populations at Postoloprty after the household method and Šatova after the ratio method are very similar to each other, as well as to those inferred from the demography of contemporary cemeteries (ca. 60-70 inhabitants). Similarly, fortified site populations (of 215+) derived from Nitriansky Hrádok in West Slovakia compare well with the results of the ratio method at the contemporary (Nowa Cerekiew) hill-fort at Jędrychowice in Polish Upper Silesia (see Note 18).

Middle Bronze Age settlement evidence is then suggestive of similar 4:1 reconstruction ratios, although after pits preserved at Vochov in West and Horní Počaply in Central Bohemia, sunken features are less volumous than their Early and Late Bronze Age counterparts. The use of sleeper-beam construction at Bezměrov in Central Moravia should also be noted at this point, although most Tumulus Culture huts employ post construction as in other Bronze Age periods.

Earlier Urnfield settlement evidence also allows for the calculation of approximate 4:1 reconstruction ratios, after Lovčičky. Population reconstructions of village sites (extending over three hectares) are quite similar (115-120 inhabitants) after both the (direct) household and (indirect) ratio methods. On the other hand, Urnfield hill-fort population estimates are hard to make, although dense distributions of surface material over 5-6 hectares are common at Knovíz hill-forts, suggestive of populations in the same order as Nitriansky Hrádok.

The Late Urnfield hill-fort of Brno-Obřany contains similar material over a 20-hectare area, although much of this material may be funerary in origin. None-the-less, a rough demographic estimate of 500 inhabitants might not be unreasonable at this latter Podolí site. A terminal use of 2:1 household reconstruction ratios for the Hallstatt B period follows from structural affiliations of Late Urnfield feature types with those of the Earliest Iron Age and Late Hallstatt periods (see Chapter 11).

Settlement concentration and primary cultivation after geo-botany

Periods of Bronze Age population concentration produce higher cultivation values after primary pollen data from alluvial sites. Pannonian pollen spectra probably attributable to the Mad'arovce period at Mýtna Nová Ves thus produce primary cultivation values of up to 3.0% of A.L.P., while Early Bronze Age values of 1.1% are attained at Vranský potok during the Únětice period in Hercynia. After a Tumulus Culture woodland regeneration phase at the latter (Hercynian) geo-botanical site, the Knovíz and Štítary extensive cultivation phases attain primary cultivation values of 2.0 and 2.3% respectively, with an intervening phase of woodland regeneration between the main Urnfield phases.

These primary cultivation values suggest that periods of settlement agglomeration occur in-phase with an expansion of arable agriculture after primary geo-botanical data, although shorter time-scale settlement minima (e.g. Hallstatt B1) may be difficult to detect archaeologically due to certain empirical limitations of the ceramic chronology.

11. Iron Age agricultural settlement of Bohemia, Moravia and Slovakia

Agricultural settlement in the Iron Age (800-33 cal. BC) of Hercynia and Pannonia is reviewed in this chapter (Figs. 117-118). Iron Age culture history recognises two main periods: an earlier phase of the Hallstatt C-D and La Tène A stages (ca. 800-375 cal. BC), and a later phase encompassing the La Tène B-D stages (ca. 375-33 cal. BC). The Urnfield system of densely settled regional polities gives way to much more dispersed patterns in the Hallstatt C Iron Age Bylany and Horákov Cultures of Bohemia and Moravia, respectively. Chamber graves containing chiefly inhumations of these cultures stand in contrast to a general poverty of settlement evidence between 800 and 650 cal. BC, when Danubian communities of small hamlets are apparently ruled by horse-riding warriors armed with iron swords and lances. A greater degree of settlement continuity is discernible in the Lusatian cultural zone in its Early Iron Age stage, although somewhat limited evidence for warrior burials also occurs in this cultural zone.

An intrusive entity originating from the East Hungarian Plain, the Vekerzug Culture appears on the now developed Pannonian steppe in the Early Iron Age (see below). Historical material cultural linkages point towards its origins from Late Bronze Age steppic cultures of Moldavia. In the Northwestern Carpathian Basin, the Vekerzug Culture is equated with pastoralist groups which at first co-mingle with local agricultural communities of the Hallstatt C era in Danubia. Small settlements at the western fringes of the Vekerzug distribution often contain an admixture of Vekerzug material with Hallstatt ceramics. However, sites with pure Vekerzug assemblages are moreover largely funerary in character, these cemetery sites usually contain either human burials with horses or sometimes horse burials *per se*. The latter funerary aspect would seem to link this group with cultures placing a great importance upon horseback riding.

Even given the probability that Vekerzug settlements are under-represented due to unknown taphonomic factors, an array of independent environmental data, both primary (in Chapter 7) and secondary (in Chapter 5) indicate that a largely steppic environment had emerged in the Pannonian aspect of the study area by Early Iron Age times. Such an environment would be ideally suited to a pastoralist adaptation, and although the traditional archaeological view of the Vekerzug Culture may be over-simplified (these communities may in fact be comprised of a mixture of farmers and herders), it seems justifiable to propose that Vekerzug groups were preponderantly pastoralist. Such groups were thus quite distinct from those Late Hallstatt communities inhabiting village settlements in Moravia and more temperate parts of Slovakia.

Ultimately, these Vekerzug groups proved to be destructive towards farming settlement in Moravia, when a marked decline in Lusatian settlement density transpires in Hallstatt D1-2. In this period, military artifacts of the Vekerzug Culture are commonly found in destruction layers of settlements of the Platěnice stage of the Late Lusatian Culture.

After a renewed formation of regional polities during the Late Hallstatt and Early La Tène, a return to hamlet-based settlement occurs in the Middle La Tène period (375-180 cal. BC), during which site populations of no larger than 50 inhabitants predominate. In contrast, the Late La Tène or Oppidum period (180-33 cal. BC) witnesses a sudden emergence of the largest settlement concentrations known from the later prehistoric era, when sites of up to 2-4,000 inhabitants occur (upland Oppida and lowland Lovosice-sites), signifying political units of an inter-regional scale. It is likely that these macro-settlements result from an indeterminate, extra-regional stimulus development rather than a regional natural increase in population. Beyond archaeology, possible extra-regional influences favouring Oppidum formation are suggested by Classical sources (particularly Poseidonios), which attest to systems of extensively integrated tribals in parts of trans-Alpine Central Europe during the later La Tène Iron Age.

Introduction of iron technology

The Iron Age in Central Europe signifies the development and diffusion of iron-working in addition to fundamental changes in the structure of settlement evidence. A precocious iron production using easy-to-reduce, oxide ores at the late Bronze Age sites of Radzovce (West Slovakia) and Brno-Obřany (South Moravia) is also notable, where Red Mountain alluvial deposits and the Moravian Karst provide the requisite hematite and limonite ores.[1] Linkage between the devolution of Urnfield cultures and the diffusion of wrought-iron working has also been suggested on the basis of the wider availability of iron ore in almost any region of Europe, as opposed to copper and tin, whose supplies depend on extensive exchange.[2]

Employing (at first) furnace temperatures not much higher than those required to cast bronze artifacts or to fire graphite pottery, the early blacksmith need only greater inputs of energy and a certain knowledge of the technology to produce artifacts much like those known previously in bronze, a production first oriented upon weaponry. By the end of the Early Iron Age, iron

1 J. Mertá of the Brno Technical Museum pers. comm., Winter 1995.

2 See Childe 1944 et al.

technology is also generally applied to the manufacture of agricultural tools.[3]

Early Iron Age culture sequence, (ca.) 800 to 375 cal. BC

Early Iron Age culture groups include the Late Lusatian cultures to the north and the Late Hallstatt cultures of Upper and Middle Danubia, while a further alien entity also appears on the Pannonian steppe, namely the Vekerzug Culture. Danubia experiences a change in material culture greater than that observable in Lusatia, as black-and-red painted pottery derived from the Hallstatt B Nynice Group in Southwest Bohemia appears across much of lowland Bohemia and Moravia in the 8th Century BC. These pigments are applied to radial triangular fields, producing the ubiquitous "star motif" (a sun symbol?). Further symbols with Urnfield roots (painted birds, wheels and sun discs) are known. Additionally, the early period betrays a predilection for bovine and equestrian subjects, with the artistic creation of terra-cotta bulls and iron horses (e.g. on Vekerzug axes).[4] The Late Hallstatt then witness the replacement of painted pottery designs by engraved ones in addition to the new application of graphite surface treatment. Finally, the use of stamped decoration during the La Tène A stage is also notable.[5]

The Late Lusatian Culture of the Early Iron Age is called after the Platěnice cemetery. Compared to Middle Lusatian (Silesian Phase) wares, form and design composition change markedly as these lose their former precise quality.[6] Diagonal incised lines in triangular zones replace concentric patterns, an indication of Danubian influence in design conception,[7] while an adoption of graphite surface treatment represents secondary trait adoption from exotic Danubian sources. Further evidence for such influence is inferred after the funerary rite, particularly in the construction of chamber graves for wealthy inhumations of the Platěnice stage, for example at Moravičany in Moravia, at Předměřice in Bohemia and at Kietrz in (Polish) Silesia.[8]

Appearing on the cultural steppe of the later Hallstatt is the Vekerzug Culture, which is often

3 Cf. Čižmář 1990, Břicháček and Beranová 1993.

4 Pittioni 1954

5 Pittioni 1928, Podborský 1974, Waldhauser 1993

6 Cf. Nekvasil 1987

7 Pers. obs. at the Moravian Museum exhibits and depositoria at Prostějov, Kroměříž and Brno, 1993-5. An "intrusive" grave of "pure" Hallstatt affiliation might also be observed in Platěnice material from Náměstí na Hané near Olomouc, where an inhumation grave of the Bylany Culture was discovered (pers. obs. at the Moravian Museum, Olomouc, 1994).

8 Stegmann-Rajtár 1993, Nekvasil 1982, Pleiner 1978, Gedl 1993

identified with pastoralist groups. Ceramic and burial usages of this culture are traceable to the Urnfields of Bessarabia and Moldavia.[9] Traits of the Vekerzug include the use of inhumation graves, the establishment of small settlements, the production of grey wares such as high handled cups and the employment of advanced iron-working techniques (used to produce a panoply of trilobate arrows, iron axes and swords). Danubian Hallstatt material also appear in Vekerzug Culture cemeteries, particularly at sites occidentally marginal to the general cultural distribution.

General settlement history of the Hallstatt C Iron Age

The beginning of the Iron Age (or Hallstatt C stage) witnesses a major dislocation of settlement systems outside the Lusatian cultural area. In West Slovakia for example, the Hallstatt C1 stage (ca. 800 to 700 cal. BC) sees the abandonment of the czernozems for moisture-retaining para-brown earths and alluvial soils (due to depressed late summer anti-cyclonic activity?). Following this poverty of habitation, agricultural settlement recovers during Hallstatt C2/D1, with a return to czernozem soils (Fig. 119). A further, partial evacuation of the black earths and is then effected in the Late Hallstatt (D2), coeval with the Vekerzug Horizon (Fig. 120).[10] Out-of-phase in relation to the settlement history of Pannonia is that of Bohemia, where after a two century poverty (Hallstatt C1-2) of settlement remains, a recovery in agrarian settlement and a formation of regional polities endures into La Tène A.[11]

The Hallstatt C settlement of Bohemia, even from the best-investigated region (Podbořany in the Middle Ohře), is discernibly sparse.[12] Of three sites of Hallstatt C age from Podbořany, only Chotěbudice produces a (single) feature in the strict sense, where excavations of a Neolithic site have encountered a sub-rectangular pit (<u>2.1 m deep</u>) with C2 stage ceramics (Fig. 122).[13] In fact, the distribution of <u>definite</u> Hallstatt C sites around Podbořany is in the order of only one locality per 5-10 km of drainage (cf. Note 12).[14] It is likely that these and other North

9 Levitki 1994

10 Pavúk et al. n.d.

11 Cf. Koutecký 1988a, 1988b, 1993, 1994, Waldhauser 1984a, 1984b et al.

12 Dresslerová (1995a) includes <u>indeterminate</u> later Hallstatt surface scatters in her comments on Bylany Culture settlement density.

13 Koutecký 1993, 1994

14 Koutecký 1993

Bohemian sites (e.g., Vikletice, cf. Fig. 121) represent only small hamlets. Also in the South Bohemian České Budějovice basin, settlement evidence consists of isolated features, for example one of Hallstatt C2/D1 date from the site of Staré Hodějovice.[15] Larger (50-100 inhabitant) settlements can be proposed for Lusatian Bohemia after finds in Silesia.[16]

Methods of reconstructing settlement populations of the Hallstatt D Iron Age

Population reconstructions of unenclosed settlements of Late Hallstatt date in Bohemia and Moravia are reviewed in this section. These data indicate a prevalence of village-level sites.

In Danubia, Classical Horákov (Hallstatt C2-D1) settlement evidence is best known from Těšetice-Vinohrady in Southwest Moravia.[17] Within the investigated area (<20%) of this 3.75 hectare settlement site, some 18 sunken features occur. These consist principally of irregular, sunken rectangular pits, 10-25 m^2 in area and preserved to a depth of (ca.) one metre. Most likely, these sub-rectangular "huts" cannot be domestic in the strict sense, thus Podborský's proposal that as many as 20 households occupied Těšetice-Vinohrady during the Classical Phase may be too liberal an estimate.[18] Further reasons for reconsidering this estimate include the finds pattern of concurrent post-built structures at Kuřim, Most and Sered'.[19]

Importantly at Kuřim in South Moravia, a recent and exceptional recovery of settlement features allows for observation of both sunken features and post-built domiciles, at a ratio of about two to one. This ratio can also be observed at the Late Hallstatt sites of Želenice (Most) in Bohemia and Sered' in Slovakia.[20] From these three sites, one might establish a general Late Hallstatt (and Štítary) constant of two sub-surface features per surface domicile. Affirmation of this "Kuřim constant" can be obtained through comparing sherd quantities per feature, which when multiplied by the sub-surface feature to domicile ratio, will produce a general sherd count per reconstructed household (cf. also Chapter 13). Presumably then, broadly equal pottery sherd counts per household will verify these population reconstruction ratios.

15 J. Militký pers. comm., 1993

16 Bukowski 1978

17 Podborský 1965

18 Podborský 1974

19 Dendro-chronological evidence indicates that Hallstatt C period begins soon after 838 BC (Harding and Tait 1989).
20 Cf. Waldhauser 1977, Paulik 1955

The Bohemian sites of Jenštejn and Březno might be used as a diachronic test of this model. For example, 44 settlement features of Late Hallstatt date at Jenštejn produce some 7,800 pottery sherds, or 177 sherds/feature, while the Knovíz occupation at Březno with 292 sunken features produce 22,165 pottery sherds, or only 75 sherds/feature. Thus the Late Hallstatt site, projected to contain half the number of sunken features per domicile in comparison with the Early Urnfield site (2:1 at Kuřim, cf. the 4:1 Early Urnfield ratio) produces sherd densities per feature which are 236% greater than those of the Knovíz period, or about 350-400 sherds per household generation. This affirmation of inverse ratios between the Early Urnfield and Late Hallstatt periods assumes that pottery sherds represent "currency units" of relative settlement intensity.[21]

In view of the derivation of the Kuřim constant, it seems likely that Podborský's population estimate (which assumes that pits reflect true domiciles) for the Hallstatt C2-D1 occupation at Těšetice-Vinohrady might be adjusted downwards to a range of 55-70 individuals.[22] A further estimate for the later (Hallstatt D1) Horákov occupation at Střelice-Slatina might also be scaled down to a range of 140-175 inhabitants on this same basis.

Conversely, demographic reconstructions by Dresslerová of the Late Hallstatt occupation of Jenštejn in Central Bohemia are too minimalist on this basis. An estimate of the extent of occupation (three to four hectares) at the site is achieved by field-walking areas adjacent to the excavation block (of 0.56 hectares).[23] However, Dresslerová is too conservative in her reconstruction of four to five contemporary homesteads, and assumes that seven to twelve large sunken features correspond to a single domicile (producing a domestic quotient about 20% of that reconstructable after the Kuřim constant, cf. Fig. 127-8). Because the entire site might contain (ca.) 314 settlement features distributed over six generations, the resultant average of 52 contemporary sunken settlement features per phase might represent the remains of 26 Jenštejn households (after the Kuřim constant), for a Late Hallstatt village of about 130 inhabitants (cf. Fig. 127 for a general perception of Hallstatt D settlement intensity after settlement feature density).

21 Salač 1984

22 Podborský (1974) uses the general class of "sunken hut" (13 in number) when determining number of domiciles, as opposed to halving the total number of significant sunken features as proposed above (resulting in a quotient of nine).

23 Around Jenštejn, two eastern fields containing Late Hallstatt pottery as 18% and 7.5% of total prehistoric pottery are not considered to be a part of the site area (Dresslerová 1995c). Because Hallstatt settlement evidence from field-walking immediately south of the excavated part of the settlement already falls to 3.3%, a failure to extend the potential prehistoric settlement area to these eastern fields is somewhat puzzling. Note in this respect that the presence of Late Bronze Age settlement in the eastern fields would surely depress the relative representation of Hallstatt pottery.

Danubian hill-forts of the Hallstatt Iron Age

Early Iron hill-fort settlements in Danubian Moravia and Bohemia are presumed, after geographical distribution data, to reflect nodes of regional polities as for the Urnfield pattern. In Moravia, a phase of hill-fort abandonment during the Early Horákov Culture (Hallstatt C1) is followed by one of re-establishment during the Classical Phase (Hallstatt C2-D1), although large sites such as the (ca.) 30-hectare enclosures at Jaroměřice and Plaveč in South Moravia are abandoned after Hallstatt D1.[24] A later (La Tène A) hill-fort is also known at Černov in Central Moravia, although this site contains only 2.3 hectares within its enclosure, reinforced by three lines of defense.[25] Large, Hallstatt D2-3 hill-forts are thus poorly represented in Moravia immediately after the Vekerzug Horizon (see below).

Hallstatt hill-forts in Bohemia tend to be later than their Moravian counterparts, and date largely to Hallstatt D2-3. In the Southwest Bohemian uplands, the extent of occupation rarely exceeds a single hectare,[26] although larger occupations occur in the lowlands, for example at Hradec (Kadaň) in Northwest Bohemia, where five hectares are occupied and enclosed by a ditch and wall circuit.[27] A highly extrapolated population estimate for hill-forts might then be derived from Prague-Podhoří (only 2% of the site is excavated), where the established duration of occupation allows for a very tenuous demographic calculation to be made after finds of 15 sunken features.[28] After the Kuřim ratio, the known quantity of settlement features and the inverse ratio of the proportion of the site excavated, it follows that some hundreds of domiciles are erected during seven generations at Prague, for a coeval population in the lower hundreds.

Lusatian hill-fort settlement until the Late Hallstatt Vekerzug Horizon

The hill-fort settlement of the Lusatian Culture zone is continuous from Hallstatt B to D1, when hill-forts of the Platěnice Phase vary greatly in size. North Moravian hill-forts are large;

24 Podborský 1993

25 Čižmář 1993

26 Chytracek 1991

27 Smrž 1991, 1992

28 Friedrichová 1974

for example, Hradisko by Křenovice extends over some 20 hectares.[29] However, later Lusatian occupations in Moravia register a retreat into smaller defensible areas of less than one hectare, for example at Rmíz and Zelená Hora. While earlier hill-forts might have served as regional centres or tribal focal points, these later Platěnice hill-forts occur largely in rugged areas away from prime arable land, and thus may represent mere refugia. These also succumb to assault in Hallstätt D1-2, with arrows of a trilobate Vekerzug ("Scythian") type occurring in destruction layers.[30] Coeval destruction deposits with trilobate arrows are also common at many South Polish Lusatian sites, which also produce representational evidence of horseman attacks.

Populations of regional polities of the Late Hallstatt

Preceded by a phase of enhanced burial wealth differentiation (see below), the development of regional polities in the Late Hallstatt Iron Age is now considered in Eastern Germany and the Czech Republic. Beginning with East Germany, Simon has reconstructed a mosaic of Late Hallstatt regional polities centred-on hill-fort occupations, each encompassing *circa* 50 km^2 in the territory of Thuringia (Fig. 114, cf. Fig. 9), based onxs intensive excavations in brown-coal areas. By way of comparison, an informal assessment of Late Hallstatt hill-fort distribution in adjacent Northwest Bohemia might also be of value due to the similar intensity of excavation of this region. Within this area, hill-forts in the reaches of the Middle Ohře would appear to be distributed at between eight and fourteen km intervals along river valleys.[31] Applying 2 km site catchments to these dendritic networks, regional settlement zones of (ca.) 40-60 km^2 might then be reconstructed.[32] Within this macro-region of the Middle Ohře, the extensively excavated micro-region of Hradec near Kadaň is representative. This five hectare hill-fort at Hradec on the Ohře would appear to be the centre of a 50 km^2 micro-region containing a total of eleven Late Hallstatt settlements (eight of which are certainly coeval in the Hallstatt D2-3 sub-phases) after intensive excavations in the brown-coal mines. Applying modal village and hill-fort populations to these sites (see Table 11.1), a total micro-regional population of level of 1,300 might be derived at Hradec and its lower tier settlements near Kadaň (Fig. 129).

29 Podborský 1993

30 Staňa n.d.

31 Cf. Holodňak 1987

32 Cf. Holodňak 1991a, Simon 1984 and Koutecký 1988a, 1988b, 1993, 1994

Funerary practice of the Vekerzug Culture

Funerary evidence for Iron Age social ranking will be considered in the following sections. Beginning on the eastern boundary of the study area, there the appears a horse-riding cultural group defined largely on the basis of graves, namely the Vekerzug of the Hungarian Plain. Large burial tumuli are known from this culture, for example the 75 m wide mound from Včelínce in Southeast Slovakia (Fig. 124).[33] The labour required for the construction of this earth-work is estimated at 7,100-12,400 man-days, indicative of a certain level of vertical ranking. Horseman graves are also occasionally (<5% of internments) equipped with jewelry, bronze mirrors and weaponry, for example at the bi-ritual cemetery of Chotín in West Slovakia.

Situated on sandy alluvial deposits, the cemetery at Chotín consists of two separate burial groups (Fig. 123). The first group (Ia) produces 247 inhumations (one equipped with a horse), 121 cremations (one equipped with a horse), one bi-ritual grave and six horse burials. Group Ib to the west contains 63 inhumations (one equipped with a horse), 31 cremations, one bi-ritual grave and two horse burials. A minority (<2%) of burials also contain hand-to-hand weaponry, consisting of four spears, two axes and an Akinakes sabre, from a total of 466 graves. Arrows are altogether more common (seemingly in both male and female graves as per "Aμαζονης"), suggestive of a dominant horse-archer component in the war bands of the Vekerzug Culture.

Chamber graves of the Bylany Culture in Bohemia

In contrast to a general poverty of settlement data, a relative wealth of evidence is expressed in the mortuary cult observable in Earliest Iron Age lowland Bohemia. In particular, the (Hallstatt C/D1) Bylany Culture of Bohemia produces a number of chambered inhumation graves with a warrior-wagon assemblage. These chambers sometimes contain horse harnesses, yokes, wagons and slashing swords of iron manufacture, for example from Hradenín in East Bohemia.

At this latter site of 86 graves, an equestrian predilection is particularly seen in three chamber graves, of which an earlier pair (24 and 28) each contain three horse harness sets for a single wagon, as well as three terra-cotta "moon symbols". This triadic symbolic set is interpreted by F. Dvořák (the excavator) as representative of the role of the Celtic horse goddess Epona, as later portrayed in Roman times with a troika of horses as the bearer of the dead across a body of

33 Furmánek and Marková 1994

water. Of this wagon grave pair, one (24) is also equipped with an iron Gündlingen sword, a type balanced for slashing from horse-back.[34] Each wagon is also equipped with yokes studded with bronze applications in a diamond pattern and three large grain storage amphorae (recalling the archaic fertility aspect of Epona, such a triple placement might be considered as apt, cf. Fig. 126). These early inhumations are uniformly placed along a north-south axis.

Graves of the Bylany Culture from Northwest Bohemia are best represented at Poláky. This cemetery in the hypothetical Hradec regional polity contains 74 graves of Hallstatt C1-D1 date.[35] A single wagon grave (21) of Hallstatt C1 date was found in addition to five graves with horse harnesses dating to Hallstatt C2. Later (Hallstatt D1) Chamber Graves 1 and 3 with horse gear also contained a mix of ceramic elements, including high-handled cups of a Vekerzug type. Unlike the earlier Hradenín graves, inhumations at Poláky are oriented from east to west, or the rite of the Vekerzug Culture. In addition to such evidence for trait-convergence between Upper Danubia and the Vekerzug Culture, down-the-line cultural exchange with the pastoralist groups is also suggested in the westward penetration of isolated "animal style" metal artifacts, for example the horse-head decorated axe from Bezděkova in West Bohemia.[36]

Chamber graves of the Horákov Culture in Moravia

The Horákov Culture in Danubian Moravia also attest to a shift from the cremation to the inhumation rite, and produces relatively rich chamber graves in Hallstatt C. The graves of the Early Horákov Culture in South Moravia comprise a group of 114 internments from 55 sites (Fig. 125).[37] Most famous is the epynomous site at Horákov at the edge of the Moravian Karst, where like the graves at Hradenín, three sets of horse gear and bowls with "star" designs are found alongside a male skeleton. This also wears a ring of gold and iron, and bears two long iron lances. Early Horákov inhumations, like their Bylany counterparts, are oriented north to south, although later graves sometimes follow a (Vekerzug) east-west axis. Later graves are also often poorer in wealth, with an increase in settlement numbers.

34 Dvořák 1936, Pare 1991

35 Koutecký and Smrz 1991, Koutecký 1992

36 Šaldová 1971

37 Stegmann-Rajtár 1992

Late Lusatian graves of the Early Iron Age

Early Iron Age Lusatian funerary practice exhibits continuity in the partial use of the cremation rite at cemeteries dating from the Late Bronze Age. Although a trajectory towards enhanced burial wealth and inferred degrees of ranking is first attested in this zone in the terminal stages of Hallstatt B, an increased expression of funerary ranking is discernible in the Hallstatt C-D period of Lusatia. For example, an Earliest Platěnice stage (Hallstatt B3/C1) cremation from Předměřice is unusual in its wealth, and contains a bronze sword of the Gündlingen type (this form is usually manufactured in iron in Danubia), Vekerzug-style iron side-tang pieces of a harness and a horse-headed sceptre of bronze (of a Vekerzug-imitating type).[38] With the Hallstatt C stage, Danubian mortuary influences are also evident in the construction of wooden chamber graves and in the appearance of triskele and wheel symbols on pottery. Three such graves occur at Kostolec nad Orlicí, each containing up to 30 vases with few metallic finds.[39] Like Danubia, a reversion to the cremation rite occurs during the Late Hallstatt of Lusatia, while the swords previously placed in chamber graves are replaced by more ceremonial daggers.

Mortuary complex at Býčí Skála

Nineteenth Century investigations by Wankel at Býčí Skála have produced rather unusual mortuary finds within this cavern in the Moravian Karst, where four culture layers are deposited in the Hallstatt D2 stage (cf. Vekerzug Horizon). At the base of the latter lay a pyre of charcoal (Layer D), upon which was placed bronze and iron artifacts, as well as grain and textiles, covered by an ante-penultimate ashy layer (C). A penultimate layer (B) of boulders was placed atop this, followed by an ultimate layer (A) of sand.[40] To the north of these layers lay an area in which was placed the remains of pig, two horse skeletons and (ca.) 40 humans, some bearing cut-mark traces on bone. More recent age and sex data on the skeletal assemblage has suggested that a more even distribution of the sexes is represented anthropologically.[41]

These mortuary rites have precise analogs in much later accounts of the votive practices of

38 Werner 1961, cf. also Podborský 1970, Dušek 1974 and Chochorowski 1984.

39 Vokolek 1991

40 Cf. Nekvasil 1985, Parzinger, Nekvasil and Barth 1995

41 Cf. Jelínek 1957, Stloukal 1981 and (esp.) Parzinger, Nekvasil and Barth 1995

Galatian tribals, telling of human sacrifices being shot with arrows and impaled by spears alongside cattle being consigned to the flame.[42] Burned metallic finds in the cave are thus unusual, and include a unique lost-wax bronze-cast bull. Other bronzes found include three ribbed-buckets and a round-bottomed bucket (containing a severed skull-cap). The occurrence of metallic Vekerzug artifacts (including trilobate arrows) is significant, given Býčí Skála's placement in the Vekerzug Horizon, with which votive activities may be connected. In the century following this horizon comes a phase of major cultural disjunction in La Tène B1.

Late Iron Age cultural sequence, (ca.) 375 to 33 BC

The Late Iron Age is comprised of the Middle and Late stages of the La Tène Culture (Phases B to D), and can be sub-divided into pre- and post-Oppidum periods at (ca.) 180 cal. BC. A high degree of cultural uniformity is apparent throughout much of Central Europe during these three or four centuries, when La Tène A stamped ceramics are replaced by red-on-white slip designs on wheel-turned pottery from the territory of Ancient Gaul to the modern province of Galicia (cf. Galatian term below) in South Poland. Other decorative properties employed on ceramics include rough vertical channeling, comb decoration, glazing and graphitic application.

Wrought-iron weaponry manufacture transforms dramatically with the Middle La Tène. From the ceremonial daggers of Hallstatt D, a development of longer blades is noticeable early in the La Tène progression, with the forging of anthropomorphic swords. Isolated finds of this type are known at Kýšice in South Bohemia and Lysice in Moravia (cf. Fig. 126). By La Tène B times, blade lengths exceeding 80 cm in iron are achieved. Weaponry emphasises hand-to-hand fighting, with the attendant development of broad-bladed spears and bossed shields.

Jewelry manufacture in gold, silver, electrum, bronze, glass and sapropelite is also elaborated at this time, with the production of bracelets and chains (for females), as well as neck-torcs and fibulae for either sex. Fibulae are important for chronological purposes, beginning with the bow-shaped Duchcov-type of La Tène B1, and ending with the slender types of the La Tène D.

The linguistic affiliation of at least some of these La Tène culture bearers is certainly Celtic (in which several sub-language groups may be recognised, see below), while Hellenic observers of these same tribals in Central Europe would apply the ethnic name Galatian to these denizens.

42 Και αλλα δε ανθρωποθασιων ειδη λεγεται, και γαρ κατετοξευασαντες κολλοσσον χορτου και ξυλον, εμβαλοντες βοσκηματα και ανθρωπους ωλοκαυτουν (Poseidonios after 135 BC, as cited in Strabo's Geography IV.6 .

The Galatian invasions of the Mediterranean in the 4th to 3rd centuries BC also denote a martial solidarity amongst the Central and Southeast European tribals so-designated.

In contrast to these new material developments in the La Tène Culture, "relict" cultures of "epi-Hallstatt" aspect have been identified in enclaves in North Bohemia and in the Western Tatras, (i.e.) the Turnov Type and Púchov Culture respectively. These cultures maintain attenuated Late Hallstatt traditions in ceramic manufacture, albeit in a restricted range of artifact types.[43] Features of Púchov Culture settlement structure and agrarian regime are also indicative of a general cultural isolation from non-artifactual innovations of the La Tène Iron Age.

Flat cemeteries and migrations of the Middle La Tène Iron Age

A wealth of evidence both archaeological and proto-historical suggests that the Middle La Tène period in Central Europe is one of tribal migration or invasion, coeval with the diffusion and dissemination of a wide range of material cultural traits in flat cemeteries beyond a (Franco-German) formative zone by socio-politically less-than complex, and yet extensively integrated local groups. Shared material traits of these tribals include a range of ceramic types, metallic artifacts and sculptural styles, as well as distinctive mortuary rites and settlement features. These material elements are cohesively replicated across land areas of $(10^{2\text{-}3+}\ \text{km})^2$ with rather minimal polythetic variation. In the middle stage of the La Tène Age, this material is mostly known from so-called flat (non-tumulus) inhumation cemeteries.

Cemetery assemblages of the Middle La Tène are notable for metallic artifacts of high artistic merit distributed widely (25-50%) through society. Female graves with up to four bronze bracelets and anklets are often encountered, as are graves with bronze chains and fibulae, although neck torcs among either sex are rare. Male graves exclusively contain iron weaponry, typically as a sword, spear and/or shield combination (Fig. 131). The proportion of warrior or rich graves varies at individual cemeteries. At Holubice in Moravia, 32% of all graves found belong to the warrior class, although less than 5% possess an assemblage typical of wealthier females, while at Křenovice (also in Moravia), 18% of graves belong to warriors, and 8% to rich females.[44] Secondary female internments lacking grave goods (thought to reflect slave-captives)

43 Waldhauser 1976

44 Čižmář 1972

are also known in primary male warrior graves in South Moravian cemeteries.

Flat cemeteries in Slovakia (where the cremation rite is important) appear to be somewhat later (reflecting a directional diffusion into Pannonia). The largest known site is Trnovec nad Váhom, where 30 inhumations and 10 cremations occur, of which seven belong to the warrior class. The earliest grave at Trnovec (233) belongs to a wealthy female wearing a Duchcov fibula. Later sites at Holare (with 25 graves, 23 of which are cremations) and Dvory nad Žitavou are poor in finds, with Holare possessing one sword grave, and Dvory none. Notably from a sample of 44 skeletons in Slovakia, three bear traces on bone of cutting or wounding. No such traces (nor female slave graves) are known from core zone sites in Bohemia.[45]

Hamlets of the Late Iron Age

Agrarian settlement during the last three or four centuries BC in Central Europe consists largely of hamlets and their associated cemeteries (cf. Fig 9). Rather than being strung-out along river valleys, the structure of Middle La Tène settlement consists of local clusters of sites separated by (ca.) three km stretches of unoccupied territory. Such community areas vary between 8-25 km^2.[46] Examples of settlements occupied over the "Duchcov Horizon" (La Tène B1) can be found in the South Bohemian uplands, at Sedlec, and in Northwest Bohemia, at Radovesice 23 and Soběsuky.[47] Similarly in Moravia and Slovakia, continuously occupied sites are to be found at Šakvice and Sered' respectively.[48] A quantitative assessment of settlement continuity is attained within the intensively studied Middle Bílina Valley of Northwest Bohemia, where settlement continuity over the Duchcov Horizon (amongst a group of 150 sites) is registered at 45% (Fig. 130).[49] Amongst these Middle La Tène sites, Radovesice 23 in the Middle Bílina Valley has been entirely excavated, as has the Late La Tène village at Bořitov in Moravia.[50]

45 Benadik 1957, cf. Waldhauser 1978, Filip 1977

46 Holodňak 1987, Waldhauser 1984a, 1984b, Podborský 1993

47 J. Militký pers. comm., Autumn 1993, Waldhauser 1993, Holodňak 1991a, 1991b

48 Horalková 1992, Paulík 1955

49 I.e. 45% of settlements with respect to total numbers of sites possessing La Tène A and B components are found to contain such components on a single site (Waldhauser 1984b, cf. Holodňak 1987).

50 Waldhauser 1993

Occupying a five hectare area at 281-295 mamsl, Radovesice 23 (Northwest Bohemia) lies on czernozems, and is occupied continuously from Late Hallstatt until Late La Tène times. Within this 500-year time-span, 492 features (including 187 post-holes) were excavated. The occupation has been divided into seven sub-horizons: with Late Hallstatt graphite ware (Horizon I), followed by La Tène A pottery with stamped decoration (Horizon II), La Tène B1 pottery with wheel-turned technology (Horizon III, or Duchcov horizon), La Tène B2 pottery with glazing (Horizon IV), La Tène C1 pottery with everted rims (Horizon Va), La Tène C2/D1 pottery with comb-wave decoration (Horizon Vb) and final a phase with faceted rims (Horizon VI or Germanic period). These sub-horizons are divided into two major phases, Phase A (Hallstatt and La Tène A finds) and Phase B (Duchcov Horizon and later finds). The first "half-sunken huts" occur in La Tène A (21 finds, representing true domiciles).[51] Later La Tène occupation is dominated by finds of such half-sunken huts with two terminal posts (26 finds), as well as somewhat larger varieties of half-sunken huts with up to six internal posts (9 finds). After Waldhauser, the Phase A population of 32 to 45 inhabitants falls to (ca.) 18 during La Tène B, before recovering slightly to (ca.) 22 inhabitants by La Tène C times.

The agricultural economy at Radovesice 23 employs iron tools, after evidence for the local manufacture of axes, plough-shares, sickles and scythes. These iron finds become more common with time. Crops at Radovesice are dominated by bread wheat, followed by barley, emmer and millet, as well as <u>legumes</u>. The patterning of these finds suggests a rotational cycle between wheat and barley which is enhanced by nitrogen-fixers.[52] The pastoral economy in the early phase is also dominated by bovines, followed by swine and ovi-caprids.

A further example of an entirely excavated hamlet of the Late La Tène comes from Bořitov in Central Moravia.[53] Unlike the horizontal stratigraphy at Radovesice, Bořitov occupies a much smaller area (ca. 1.5 hectares), which lies on a sandy height some 330-340 mamsl. The hamlet settlement is occupied during the La Tène D1 sub-phase only, a period of about two generations, which produces 15 semi-sunken-huts. The fact that <u>no</u> cross-cutting relationships occur

51 It should be noted here that the average of the range of Hallstatt D and La Tène A post-built structures (45) is nearly half that of the number of significant sunken features (excepting "shallow pits", cf. Hallstatt D Kuřim ratio).

52 Tempír n.d.

53 Čižmář 1990b

amongst these further reinforces the impression of brief occupation, during which eight houses are simultaneously occupied, for a coeval population of (ca.) 40 individuals.

Larger Late La Tène sites

The Late La Tène Age (C2/D1) represents (ca.) five generations (ca. 180 to 50 ca. BC), a short period of profound settlement development, with the emergence of a group of unenclosed settlement agglomerations of up to 20 hectare extent which appear near major river systems, the so-called Lovosice-type sites. At the upland periphery of the primary (lowland) agricultural zone there appears even larger and heavily fortified settlements, the so-called Oppida.

Macro-settlement in the lowland zone is best documented at Lovosice at the confluence of the Elbe and Ohře in North Bohemia (with analogs at Mšec, Prague and Kolín).[54] The site occupies a long, unenclosed strip of land at least 20 hectares in extent where intensive settlement evidence has been found during the course of salvage operations. One small excavation (192 m^2) uncovered remains of 18 sunken features, as well as post-holes and (compound-enclosure?) grooves. A most-recent exposure some 20 m long in the town square revealed also a 30-50 cm thick grey-ashy culture layer of Late La Tène date.[55] The character of finds from Lovosice are much like that to be found at the Oppida: iron tools and their fragments in great quantity, evidence for metal-working of every kind, as well as evidence for rotary quern production.

Staré Hradisko and Oppidum populations

The Oppida of Bohemia and Moravia are much larger than earlier fortified sites, and range in size between 20 and 40 hectares. Their lines of defense are truly substantial, and often consist of multiple lines of walls and ditches with complex gateways and defensive outworks upon hill-top positions (Fig. 132). Within these sites, ample evidence for industrial and agricultural activity is to be found, consisting of iron foundries, smithies, bronze, glass, sapropelite and pottery workshops, coin-mints, agricultural tools and rotary querns. Rather than being distributed into special quarters, traces of these activities are evenly distributed throughout suburbs and acropoli, as constituted by palisade-enclosed compounds of (ca.) 0.1 hectare extent.

54 Salač 1991, 1993

55 Pers. obs. at site excavations by J. Blažek (et al.) of the rescue archaeology unit (U.A.P.P.) at Most, Autumn 1994.

These multi-family compounds of industrial activity are thus actually units of agrarian settlement. Within the Oppida, these compounds are then arrayed like cells separated by paved road- and track-ways (i.e., their layout is not truly differentiated, and thus "urban"), although cult centres within certain Oppida are known. Internal population densities on Oppida are best attested at Staré Hradisko near the eastern edge of the Drahanské Vrchovina in Middle Moravia.

Lying on a hill elevated 90 m above the surrounding terrain, Staré Hradisko is divided into two occupation zones of unequal size, a "suburb" of 13.5 hectares, and an "acropolis" of 23.5 hectares (Figs. 133-134). In the 0.485 hectare area of the suburb excavated by Meduna, 22 half-sunken-huts occur, as well as four kilns, coin moulds, gold coins with horse-symbols and extensive evidence of iron-working, including fragments of bridles and riding spurs.[56] Further excavations of 0.695 hectares within the suburb and acropolis produced evidence of three compounds, each estimated to be about 900 m^2 in area, within which were found more fire-places, kilns, and masses of metal work.[57] Within the total 1.2495 hectare area investigated (representing 3.4% of the entire site), 115 large rotary querns were found. Extrapolating from this basis, the entire Oppidum might contain 3,800 rotary querns. Such a mass quantity could have been produced over the five generation period of occupation only if the site population had numbered in the lower thousands. This inference is believable when extrapolating from the estimated total number of half-sunken-huts within Staré Hradisko (1,650 huts), which divided over five generations produces a quotient of 330 households (not including post structures). Population densities as high as 100 inhabitants per hectare have thus been proposed by Waldhauser for intensively occupied Oppida such as Staré Hradisko (37 hectares) and Závist in Central Bohemia (34 hectares), although excavation at the latter site has concentrated largely upon the fortifications, gateways and acropolis area.[58] Smaller Oppida such as Hostýn (note that "-týn" is derived from the Gaeolic "-dun") in East Moravia (19.5 hectares) also seem to have been intensively occupied, although less certain is the status of the large 80 hectare fortified plateau at Uhošt' in Northwest Bohemia (590 to 600 mamsl), where finds are not plentiful.[59] With such limitations borne in mind, population levels of 2,000 to 4,000 at larger Oppida might

56 Meduna 1970

57 Čižmář 1989

58 Mýtková et al. 1991, Waldhauser 1984a, 1984b

59 Waldhauser 1991

be proposed. Similar populations are probably found at lowland Lovosice-type sites.[60]

Small hill-forts of the Púchov Culture

In contrast to developments of the La Tène Iron Age, the hill-top settlement of the "epi-Hallstatt" enclave of the Púchov Culture in the Western Tatra foothills occurs on a much smaller scale. The situation of Liptovská Mara is typical (enclosing an area of less-than one hectare at 690 mamsl). The ceramic assemblage consists of hand-made epi-Hallstatt types, cross-dated by occasional La Tène D fibulae.[61] East Moravian hill-forts of the Púchov Culture are also known at half-a-dozen localities, of which only Požaha by Jičina has been tested, revealing traces of post-houses and small storage pits.[62] An attenuated "Bronze Age-like" botanical sub-fossil assemblage was found, consisting of emmer and einkorn wheat, barley and pea. This latter fact is suggestive in itself of a removal from economic trends witnessed in La Tène communities, as some new cultigens (e.g. Avena) would be well suited to upland environments. The faunal assemblage at Požaha is also unusual, with (ca.) 50% of identified bones belonging to wild animals. Such a proportion of hunted game would seem to be obtainable only by populations whose base-level population is much lower than that of the Late La Tène macro-sites.

Evolution of Iron Age agriculture

Respecting the ecological innovations of Iron Age agriculture, new cultigens appearing as weeds or as incidental crops during the Late Bronze Age become more important in the Late Hallstatt, particularly rye (*Secale cerealia*). The rye crop, far hardier than most wheat species in both cold and hot weathers, increases in its representation in Poland and Bohemia during the Hallstatt Iron Age.[63] In Poland, small but pure samples have been recovered from Late Lusatian lake-fort assemblages which date to Early Hallstatt D.[64] As a particularly hardy winter crop, rye might be expected to have extended the growing and harvest season over a longer span of the

60 Cf. Waldhauser 1981

61 Pieta 1971

62 Čižmář 1991

63 Zohary and Hopf 1988

64 Klichowska 1984

year, although its addition might not have been as necessary in the warmer climes of South Slovakia, where extensive finds of the corncocke weed (*Agrostemma githago*, also indicative of winter-sowing) with barley occur at Čečejovce. Rye appears at 25% of sites in Bohemia, while spelt wheat continues to be important in Slovakia, appearing at 27% of sites.

A further innovation of Iron Age agriculture is the cultivation of oats (*Avena sativa*) across East-Central Europe, for example at Pod near Bugojno (Bosnia), where (ca.) 10,500 grains and rachis fragments were found.[65] Within Bohemia, finds are known from 33% of sites of the Hallstatt Age.[66] Late in the La Tène sequence, oats appear at 47% of sites in Slovakia, often in association with the corncocke (e.g. at Bratislava-Podhradie).[67] The addition of oats as a major part of the diet also has important philological implications. The early use of *Avena sativa* as an animal feed is implied by the linguistic association between the word for "oats" and "sheep" in both Latin and the Slavonic languages (cf. "oves" and "ovce" in Czech). Amongst the Gaelic languages however, a more central role to the diet is implied by a syntactical association between "bread" and "oats".[68] Thus the pervasiveness of *Avena* in the macro-fossil record of the La Tène Iron Age in Central Europe might be inferentially attributed to the Gaelic communities of the La Tène Culture. For example, oats are found only in late contexts of the Púchov Culture at Liptovská Sielnica, where its presence is noted together with the appearance of Late La Tène ceramics on-site.[69]

Bread wheat (*Triticum aestivum*) became the most important of the corn crops in the Hallstatt Iron Age in Bohemia, and later, in the La Tène Iron Age in Slovakia. A greater productive potential of its larger grains is no doubt a factor in its eventual selection over emmer.[70] At lowland sites such as Radovesice, a two-crop rotation system might have already emerged, first in the Early Iron Age between bread wheat and barley or rye after Tempír, with the additional cultivation of oats to this two-crop system in the La Tène Iron Age by Gaelic (?) peoples.[71]

65 Kučan 1984

66 Cf. Wasylikowa et al. 1991 and Tempír n.d.

67 Cf. Hajnalová 1989, 1990, 1993

68 Markey 1989

69 Cf. Pieta 1971, Hajnalová 1993, the younger E. Hajnalová pers. comm., 1995.

70 Wasylikowa et al. 1991, cf. Hajnalová 1993, Zohary and Hopf 1988

71 Tempír n.d.

The increased importance of nitrogen-fixers such as pea, lentil and bean is a development whose importance should not be under-rated. By promoting the recharge of vital soil nutrients through the biological activities of rhizomous bacteria, these plants improve the prospects for more intensive crop-rotational systems. In the Czech and Slovak Republics, the proportion of nitrogen-fixers in examined crop assemblages increases by at least 100% over Bronze Age times, with the pea represented at 55% of sites of Hallstatt date within the latter republic.[72]

The development of wrought-iron manufacture of agricultural tools is first attested during the Late Hallstatt and Early La Tène period, for example at the Černov hill-fort in Moravia, where a depot containing an ard-tip, three axes, a chisel, a palstave, two small hand-knives, a large sabre-like knife and a key was found.[73] Other iron finds demonstrate the evolution of true scythes (bronze-alloy is too soft for such a long implement) from the primitive sickle, a development which would have enabled the establishment of true hay-meadows.[74]

Respecting "ideological" constructs relating to agro-climatic conditions, the introduction of a new votive type, that of the Náklo water-bucket, might also be understood as a kind of precipitation or fertility invocation. Such bronzes appear in groups of three or four at cultic sites. Most demonstrative of such deposits is that from Býčí Skála cave, where three such buckets occur near a funerary pyre. Votives to the goddess Epona might also be understood as an invocation to water as reflected in the placement of two horses in the cave. These rites also have analogies in the "druidic" sacrifices described by Poseidonios (cf. Note 43).

Population dynamics and the evolution of Early Iron Age agricultural settlement

The most significant settlement development of the Early Iron Age is the initial low-density pattern of micro-settlement structure in the Hallstatt C period in contrast to the Štítary period within the Danubian zone. Bohemian settlements are particularly small; but after evidence of deep and wide features at Chotěbudice and Vikletice, one can discount the agency of erosion of superficially built features as a blanket behaviouralist explanation for this phenomenon.

In Moravia, concentrations of deep rectangular features are suggestive of the establishment of larger (in comparison with Bohemia) settlements at the hamlet-village population boundary by

72 Wasylikowa et al. 1991

73 Čižmář 1993

74 Břicháček and Beranová 1993

the late Hallstatt C period. Within this Danubian territory, hill-fort settlement along with a dense lowland settlement net is also reestablished during the Hallstatt C2 sub-phase. These developments probably occur in tandem with the reestablishment of regional polities which are preceded by "equestrian-warrior" chamber graves. Much like the Late Bronze Age pattern, enhanced burial wealth in the Early Iron Age emerges *circa* 100 years prior to the appearance of settlement complexity (cf. Urnfield establishment phase of Chapter 10).

At the terminus of the chamber grave period (Hallstatt D1), funerary assmeblages of the Vekerzug Culture of the Hungarian Plain produce only a small proportion of (symbolic) warrior graves (ca. 2%). The great mass of mortuary tumuli such as that at Včelínce furthermore attests to degrees of vertical ranking among these pastoralists, as it seems that such structures were devoted to a single family group. Inter-regional elite interaction between the Vekerzug pastoralists and farming communities is also reflected in an equestrian artifactual repertoire found in the Danubian provinces of the Horákov and Bylany Cultures of Moravia and Bohemia.

A later Hallstatt agricultural recovery is effected, coincident with the first use of iron in farm tools, the introduction of hardier cultigens, the increased use of leguminous nitrogen-fixers and the secular incidence of a warmer, drier agro-climate.[75] Greater population densities achieved in Hallstatt D might then be attributed to these favourable climatic conditions which ultimately enable a general population rise. Bohemian settlement densities grow at a slower but steadier rate, reaching their Early Iron Age maximum by Hallstatt D3, when a mosaic of regional political units (on an Urnfield scale) is reestablished across much of Central Europe.

Conversely, by the Hallstatt D3 stage, the agrarian settlement structure of Pannonia has largely contracted into small hill-forts which seem to have played a refugium role. The factor of pastoral nomadic encroachment in this development may be suspected during the Vekerzug Horizon (Hallstatt D1-2), which witnesses the destruction of many settlement sites, particularly in the Lusatian cultural zone of Moravia. Notably, this horizon is coeval with a reconstructed phase of relatively xeric climate on the Pannonian steppe, after primary geo-botanical data presented in Chapter 7.

By the beginning of the Middle La Tène, hill-fort and village settlement throughout Central Europe has devolved into small hamlet sites in micro-regional clusters of the Duchcov (La Tène B1) horizon, coincident with the full development of a cool, wet, Sub-Atlantic agro-climate. Development of this later Iron Age period will now be considered.

75 Cf. Klichowska 1984

Although dispersed into hamlets with small cemeteries, Middle La Tène Culture bearers achieve high technological expertise in metal work and pottery manufacture which comprises a virtual unity from Gaul to Galicia in South Poland. This unified (post-Duchcov horizon) cultural entity also intersects the geographic focus of the ethno-historic designation "Galatian" used by Poseidonios after 135 BC (the Early Oppidum period), as is later related by the Greco-Roman geographer Strabo. Linguistic implications need not follow from this ethnic designator, although it is highly probable that some Galatians (the Boii of Bohemia) spoke a form of Celtic. Note then the "týn" or "fortified homestead" toponym, derived from the Celtic "dun" in Czech place names such as Týniec, Týn-nad-Vltavou and the Oppidum of Hostýn, and compare also hydronyms such as "Alba" and "Elbe" amongst others, in addition to identical, linguistically associated names minted on coinage between Czech and Slovak sites and finds in Gaul proper and Southern Britain (e.g. "BIATEC"). Such is the summary contribution of philology to the question of La Tène settlement. Other examples may be omitted for present purposes.

In the settlement archaeology of this period, half-sunken rectangular features are treated as domiciles.[76] Although physically, no recognisable nodes of control appear in the Middle La Tène settlement record, concurrent Classical sources describe large (1000+ member) war bands among tribals of this period.

In addition to describing large concentration of La Tène Age populations, peculiar tribal-social relationships of the La Tène Age are discussed in Classical sources. Of particular interest are eye-witness accounts in trans-Alpine Europe by Poseidonios in Book IV.6 of Strabo. Therein follows then a well-known description of the tribal cohesion of Late La Tène Galatians in Central Europe (written after 135 BC, broadly coeval with later La Tène C): ο νυν Γαλλικον τε και Γαλατικον καλουσι αρειμανιον εστι και θυμικον τε και ταχυ προς μαχην, αλλως δε απλουν και ου κακοηθης. Δια τουτο επ–εθισθεντες μεν αθροοι συνιασι προς τους αγωνας προς και φανερως και ου μετα περισκεφεως, literally, "now these who are called both 'Gallic' and 'Galatian' are filled with the spirit of Aries and are quick to battle, otherwise they are simple and without malice. It is through this excitability that large hordes, openly and without circumspection, are gathered together towards the place of contest". The reactions of these

76 Cf. Salač 1995

Galatians to injustices done to their kin are of interest in this context: συνιασι δε κατα πληθος ραδιως δια το απλουν και αυθεκαστον, συναγανακτουντων τοις αδικεισθαι δοκουσιν αει των πλησιον, literally, "(they are) readily gathered together through their multitude by virtue of their directness and guilessness whenever an injustice is done to them by their neighbours". The final word (πλησιον) is revealing, as it suggests that tribal cohesion exists only in a relative sense, it being made manifest in reaction to a specific threat or insult felt by any aspect of the tribal body. The idiomatic sense of κατα πληθος ραδιως is also intriguing, connoting a sense of rapid communication of social obligation through populations.

Without recognisable political centres or definable elites, these Galatian tribals are thus nonetheless seemingly capable of mustering considerable forces under some unknown organisational principle, certainly one beyond the scope of localized tribes. Hypothetically, from sources of ethnography, an inferential analog to such an integration principle is known as the "linear segmentary tribal lineage" (see Chapter 2). In short, this lineage system is a non-hierarchical ordering of clan segments by degree of kin-relationship to common ancestors.[77] It is the reactive realisation of these relations in the context of war that sets linear segmentary lineages apart from a linear, chiefly system of conical clans. Thus, lateral tribal solidarity in war is achieved with more limited vertical social controls.

By virtue of this principle of "complementary opposition", the more distant the relationship of the tribal foe, so much the greater is the reactive tribal body to be reckoned with. Intra-tribal warfare is thus discouraged while extra-tribal "predatory expansion" is encouraged. Classical references to large Galatian war bands are thus rectified with more modest settlement modes (esp. those of the Middle La Tène period), while the occurrence of para-mortal violence on skeletal material and the appearance of possible slave-graves at the southern periphery of the La Tène distribution are also explained by the same principle of complementary opposition.

Dynamics of population concentration in the Late La Tène Iron Age

Populations of the Late La Tène period achieve settlement densities unmatched in prehistory. Applying the demographic constant after Waldhauser (100 inhabitants per hectare), one may propose concentrations from 2,000 to 4,000 inhabitants at Late La Tène macro-sites. Rather than a mere doubling or tripling of lowland village populations, an increase of two orders of

77 Cf. Service 1962, Sahlins 1961, 1968 and Evans-Pritchard 1940

magnitude is observed in both lowland (Lovosice) and upland (Oppidum) situations (cf. Table 11.1). Is it possible that natural growth can account for such macro-settlement development?

Towards an answer to this question, one must recall once more the demographic study of Furmánek, where a near-optimum (realistic) annual growth rate of between *r* 0.005 and 0.006 is reconstructed during the climatic optimum of the Early Urnfield period in the Carpathian Basin. Of probable lower amplitude is the improvement in the Central European Latest Iron Age agro-climate, although new iron technology and new cultigen strains have made this Iron Age agriculture more robust with respect to minimal growing conditions.

In view of these facts, one <u>cannot</u> expect that population growth at a <u>theoretical</u> maximum of *r* 0.02 can be sustained at the transition to the Late Iron Age (i.e. the end of La Tène C1 until the beginning of La Tène D1), a transitional period of about 60 years (ca. 180 to 120 cal. BC).[78] However, because the Middle La Tène period itself witnesses no observable settlement growth, this demographic transformation must have been effected within this latter (ca.) 60 year period.

Table 11.1. Inhabitants per settlement for the Iron Age in Bohemia, Moravia and Slovakia

Chronological Period/site type	*Bohemia*	*Moravia and Slovakia*
Early Horákov settlements	n/a	ca. 55-70
Late Horákov settlements	n/a	ca. 140-175
Bylany Culture settlements	ca. 5/hectare	n/a
Late Hallstatt village sites	ca. 130	n/a
Late Hallstatt hill-forts	lower hundreds	as per Bohemia?
La Tène Hamlets	ca. 20-40	ca. 20-40
Late La Tène Lovosice-sites	ca. 2,000	as per Bohemia?
Late La Tène Oppida	ca. 2,000 to 4,000	ca. 2,000 to 4,000

Should a most-liberal scenario of sustained growth, (ca.) 160% of that derived by Furmánek for the Early Urnfield Bronze Age in Slovakia be applied then to the Late Iron Age in Bohemia ($r = 0.01$), how might this exercise be informative as a test towards the relative likelihood of the natural (regional) *vs.* stimulated (inter- or extra-regional) demographic growth scenarios in the

78 Cf. Furmánek 1994, Neustupny 1983

formation of Oppida and Lovosice sites? To begin, one must first estimate initial and consequent population levels of the Middle and Late La Tène periods respectively, focusing upon the demographies of well-investigated hamlet-based settlement regions of the former, and the large Oppida and Lovosice sites of the latter period.

The Middle La Tène settlement system in Bohemia as a whole is best-known in the Middle Bílina Valley in Northwest Bohemia, where between 65 and 95% of original La Tène settlement has been recovered in the wake of open-cast mining activities. The settlement system of this region of (ca.) 236 km^2 (under 350 mamsl) has produced 18 micro-regional settlement clusters of (ca.) 50 inhabitants each, consisting of one or two hamlets (cf. Fig. 130). The total population of this macro-region, of which there are (ca.) 100 comparable areas in Bohemia, might then be put at (ca.) 900 individuals. This would imply that a minimum trans-Bohemian population of (ca.) 90,000 can be reconstructed in the Middle La Tène Age.[79] Given then the most optimistic realistic natural rate of growth proposed above, this territorial population could grow maximally to (ca.) 164,000 within the (ca.) 60 year period between the end of La Tène Phase C1 and the beginning of La Tène D1.

By implication then, the consequent Late La Tène population of Bohemia is hyper-agglomerated, with minimally five Lovosice sites in the lowlands and six Oppida comprising a minimal macro-settlement population of 22,000, or one third of the maximum-possible natural increase for the whole of lowland Bohemia. Thus, even a maximal natural increase can account for macro-site formation only in an inter- or extra- regional context, implying in turn an effective political integration of populations in the order of 5-10,000, inhabiting a multiplicity of stream and river valleys. The proposed natural increase thus implies a minimal "territorial catchment" needed to populate these macro-sites, assuming complete migration into Oppida or Lovosice situations. Based on the area of prime farmland (below 350 mamsl), this catchment is estimated to extend at least 220 km^2, although tribal territories are probably considerably larger.

Still more problematic is the assignment of an economic or social "function" to the upland Oppida, sites completely redundant to the agricultural, industrial and socio-ideological needs of lowland communities, as the latter are already well-furnished with iron-works, rotary quern workshops, temple sites and so-on.[80] What remains striking then is the inaccessibility of

79 Holodňak 1987, Waldhauser 1981, 1984a, 1993

80 Venclová 1995, Salač 1993 The temple compound and industrial area at Mšecké Žerovice in Middle Bohemia is one such example.

Oppidum sites and their attendant scarcity of prime farmland. Thus the Oppida are actually marginal sites, central only in the sense of their large populations inexplicably assembled.

Amongst other explanations of Oppidum formation, could it not be that one extra-regional stimulus for these enigmatic Oppidum-sites comes from returning Galatian war bands, (a.k.a.) the raiders and mercenaries known from later Hellenistic Civilisation? These reintegrating tribals might have imposed a new political order on their erstwhile lineal relations, with the establishment of fortified strongholds at the margins of the primary agricultural zones. Suggestive of such Classical societal influences, numismatic systems of social exchange are known from the Czech and Slovak Oppida which employ a Hellenic-derivative coinage, initially based on the silver tetra-drachma (and later, Roman gold coinage).

Finally, later La Tène coins from Bohemia and Slovakia bear appellations known also to the Oppidum zone of lowland Britain and parts of Gaul, implying a commonality of trans-European social contacts, if not identity. Such a laterally-extensive social order may have been expressed as an equality amongst its leading members, reflected in the establishment of segmentary compounds in the Oppida, but such settlement was of short duration. By 33 BC, all Oppida in the Czech Republic save Třísov in deep South Bohemia are abandoned without violent episode.

Review of Iron Age demographic reconstructions

Settlement population reconstructions of the Iron Age derive entirely from the ratio method in the earlier period, and from (direct) domicile finds in the latter. The earlier Iron Age 2:1 ratio observed at Kuřim, Sered' and Most actually originates in Hallstatt B, when the micro-structure of settlement sites of the Podolí-Štítary period universally include large storage pits and oblong to sub-rectangular sunken features, in addition to post-built structures serving as true domiciles. Application of the (2:1) Kuřim ratio to sites of the Late Hallstatt produces population estimates quite proportionate with village and hill-fort sites of the Late Bronze Age. Notably, the regional structure of the settlement system is quite similar for these two maximal periods, although the intervening site populations of Hallstatt C date seem suspiciously low, and are expressed as a function of density rather than as definably discrete population concentrations.

Later (La Tène) Iron Age population estimates derive almost exclusively from half-sunken hut features. Unlike prior pseudo-pit-houses, La Tène half-sunken huts are very regular in plan (throughout Central and Southeastern Europe) and uniformly commodious. The latter huts also contain clear evidence for ceiling support posts and even floors of a relatively shallow depth (ca. 30 cm). Because such half-sunken features are somewhat prone to erosional vectors, only high-standard excavations are considered in respect to La Tène Iron Age population reconstructions.

Iron Age settlement concentrations and primary geo-botanical evidence

Primary geo-botanical evidence for Iron Age agricultural settlement is quite extensive. From Bohemia, the sites of Vranský potok and Vinoř provide insights into micro-regional and local floral responses to Early Iron Age agricultural practice. Equivocal with the settlement record, relative continuity of micro-regional agrarian practice from the Hallstatt C to the Late Hallstatt is indicated in rational, modal primary cultivation values of (ca.) 1.0-1.5% exhibited at the principal site of Vranský potok (at the margin of the primary Bohemian settlement cell). In contrast, an increase in agricultural intensity is indicated from local Hallstatt C2 and D spectra from Vinoř in the Central Bohemian settlement cell as primary cultivation increases from less-than 1% to 4.6%, more in-phase with apparent developments in settlement archaeology.

To the east, Early Iron Age spectra from the South Moravian Horákov sites at Vojkovice and Pohořelice are indicative of a general drying trend on the northwestern margins of the Pannonian steppe between Hallstatt C1 and D1-2. Notably, a xeric signal of the latter period from Pohořelice is also coeval with discerned Late Hallstatt pastoralist incursions into Central Europe.

La Tène Iron Age spectra from Vranský potok are furthermore in-phase with archaeologic evidence; for example, in the woodland regeneration phase of the Middle La Tène settlement minimum and an acute increase in cultivation coeval with the Oppidum period. Because a rational-level increase in cultivation is not achieved in the latter period, a scenario of high natural population increase towards the Oppidum age is not supported in this micro-region, however. Such independent geo-botanical lines of evidence would seem to support the contention made in this chapter that levels of population amalgamation witnessed in larger Late La Tène settlement communities is a product the direct political integration of formerly dispersed hamlet settlements.

12. Roman Iron Age agricultural settlement Bohemia, Moravia and Slovakia

Archaeological and historical sources for the proto-historic or Roman Iron Age agricultural settlement of the Czech and Slovak Republics, as well as similar sources for the Imperial Roman invasion of these territories during the Marcomannic Wars (AD 166-180) are reviewed in this chapter (Figs. 135-136). In terms of culture history, two main periods are recognised: an Early (33 BC to AD 180) and Late (AD 180-400) Roman period. Settlement patterns of the post-AD 400 Migration period are also considered as the terminus of the cultural historical treatment.

Subsequent to the peaceful collapse of the Oppidum system, macro-sites are replaced by a dense settlement network lacking in recognisable nodes of control. Ethno-historic Classical sources none-the-less attest to a degree of tribal integration not definable in the archaeological record alone. Most-likely, the focus of integration is martial rather than cultic or politico-economic.

Following the Roman invasion, a less dense settlement network of hamlet-sized sites emerges during the Late Roman period. Linkage of these developments with the destructive aftermath of the Marcomannic Wars is problematic, however environmental data are also indicative of denuded agro-climatic conditions after (ca.) AD 200 which might limit population levels. A certain micro-mobility of settlement systems then inferable accords well with historical sources for Central European tribal migrations of this final period.

Proto-historical background

The Roman Iron Age (33 BC to AD 400) belongs to proto-history. Its treatment will include both historical and archaeological documentation of the Marcomannic Wars (AD 166-180) in Moravia and West Slovakia. The period begins when during the course of border conflicts with Rome, the Germanic Moraboduus and his Upper Danubian tribesmen sue for peace in AD 6, leading to his installation as a subject "client-king" in the land of the Boii, "Boiihaemum" or Bohemia. Of the tribes subsequently "ruled" by Moraboduus as listed by Strabo's Geography (IV), quite a mixture is apparent. Amongst the "transparently" Germanic tribes are the Marcomanni themselves, the Suebians and the (East Germanic) Goths. After ruling as titular head of this tribal coalition for thirteen years, the imposed Moraboduus is deposed by the Goths and returned to Ravenna, where the Romans hold him hostage until his death in AD 35.

The interval (AD 35-166) is one of relative peace on the Middle Danubian *limes*, when Tacitus compiles his "ethnography" of the Germanic tribes. Tacitus refers to these tribes as "readily migrating" (although not necessarily nomadic), while the inhabitants of the steppe are called Γαλακτοφαγοι or "milk-eaters", a reference to the dairy-rich diet of Pannonian pastoralists.

It is such farmers and pastoralists who band together in AD 166 to cross the *limes* into Noricum and Pannonia, a horde said by Cassius Dio to have numbered 6,000, led by Ballomar of the Langobardi ("long-beards") and ten "kings". The invaders are subsequently defeated by a full legion sent from Brigetio. Given the strength (5,000+) of the latter body, the number of barbaric invaders cannot be too highly inflated. It is this incursion which triggers a long war of the Marcomanni (of Bohemia and Moravia) and Qvadi (four tribes of Slovakia?) with Rome, a war lasting through the reign of Aurelius until the ascension of Commodus fourteen years later.

The Romans encounter many difficulties during their wars on the Marcomannic-Germanic tribes. After ten inconclusive campaigns leading to a truce in AD 175, a (premature) Roman triumph is declared in honour of Marcus Aurelius. This truce lasts but two years, after which a Roman force of up to 40,000 is deployed to begin a war of attrition. Concentrating efforts first upon the Marcomanni (up the Morava) and then upon the Qvadi (across the Danube), the Romans are said by Dio to have "hampered peaceful agriculture" (to starve out the tribesmen), a campaign presumably effected by regular raids on native agrarian communities. By AD 179, conditions for agriculture had grown so adverse that the Qvadi are said to have attempted a mass migration to the north, only to be intercepted by Roman troops (leading to a mutually bloody battle). With the natural death of Aurelius and eastern border conflicts arising with Parthia, a relative peace is made on the Middle Danube by the new emperor, Commodus in AD 180.

The original intention of the Romans to incorporate the lands of the Marcomanni and Qvadi remained unfulfilled, despite the continuous deployment of three legions (X, XI and XIII), auxilia and allied cavalry units over a 14-year period.

Roman Iron Age cultural-historical background

The geography of the culture history of the Roman Iron Age is one of relative simplicity, in which only minor inter-regional differences in material culture are apparent. It is during this period that the "epi-Hallstatt" Púchov Culture enclave in the East Moravian and West Slovakian highlands is absorbed, while in the lowlands, transitional site contexts containing mixed assemblages of Late La Tène and "Early Germanic" pottery negate simplistic models of population replacement which attempt to account for changes in material culture. Equally reductionist notions of a completely formal and autochthonous cultural evolution are insufficient to account for every material cultural change, however, for during and after the Marcomannic Wars, not only isolated artifacts but also full, discrete assemblages of "Elbe Germanic" (at Kostolec na Hané) and Przeworsk (in parts of Slovakia and Moravia) cultural derivation infiltrate southwards into the focal study region, representing part of a complex process of ethno-genesis.

The ceramic inventory of the Early Roman Iron Age (Eggers B1-2) is dominated by well-fired graphitic pottery, usually decorated in dense, symmetrical patterns, consisting of meanders, diagonal channeling in triangular fields and comb-incised designs, while types consist largely of bowls, urns and pots. Late Roman (Eggers C-D) pottery tends to be simpler in design conception and more restrictive in formal range, and graphitic and wheel-turned pottery also become rare. Of (Polish) Przeworsk derivation are more sparsely decorated pots with pits and isolated channels, while of "Elbe Germanic" derivation at Kostolec are pots bearing pit and channel decoration in different patterns with zig-zags and metope-design channeling. Costume elements (esp. fibulae) link this group with a later Langobardic occupation of Pannonia. Przeworsk pottery appears in Moravia beginning with the Marcomannic Wars (Eggers B2/C1), while Elbe Germanic pottery is known during the Eggers C phase of the Roman Iron Age.[1]

During the second half of the Second Century AD, the Púchov Culture finally loses its distinctive material cultural cohesion as its forms fuse with material elements of the Przeworsk Culture in the wake of the Marcomannic Wars.[2] The possibility that successive Roman invasions between AD 166 and 180 and a reconstitution of tribal society contributed to this disintegration is reflected in Roman booty taken by Przeworsk tribals during the Marcomannic Wars. These military artifacts appear at "intrusive" Przeworsk sites of the terminal Puchov period; for example, a legionary *pilum* from Kalná nad Hronom (taken during the Aurelian campaign?) and a Roman dagger from Tuchnýa in West Slovakia.

Perhaps the best chronological markers of the Roman Iron Age (besides imported Roman vessels) are fibulae, as systematically cross-dated with Roman material culture. Of Early Roman Iron Age date are stubby forms with ornate arches and cross-springs. During Eggers C-D, fibulae become longer with simpler arches bowing outward, and lacking in cross-springs. Also

1 Tejral 1992, Zeman 1961

2 Pieta 1994

of potential steppic derivation are the occasional plate brooches, the latter being elaborated with decorative pellets and other minutiae.[3]

Weaponry from the time of the Roman Iron Age is narrower in its range than that found in the flat cemeteries of the Middle La Tène. Almost without exception, the (rare) spear is the main weapon, sometimes accompanied by spiked conical shield bosses. In addition to native finds, Roman ceramic and metallic imports are encountered on occasion. Although occasional sherds of Samian Ware are known from modest domestic contexts, more impressive metallic vessel collections occur in rich graves of what might be termed "Roman collaborators" (see below). With the gradual Roman integration of the Germanic Feoderatae and the disintegration of the Imperial system during the 4th Century, Late Roman Iron Age (Eggers D) ceramic forms also exhibit a certain affiliation with Roman metallic vessels. Decorative attributes are independent of Roman influence, however, with the wave motif (a property known first from the North Bohemian Kobyly Group)[4] rising to a new prominence.

Settlement populations of the Roman Iron Age

The basic element of settlement archaeology in the Early Roman Iron Age is the "half-sunken-hut". Like the domiciles of the La Tène Iron Age, these are of shallow aspect, being dug to (ca.) 30 cm (i.e., these are not simply large settlement pits). Unlike the dual posters of the La Tène Iron Age, Early Roman huts are built of six posts, two-to-a-wall with dual axial terminal posts.[5] The evolution of the latter house form is not abrupt; however, because mixed assemblages of Late La Tène and Early Roman pottery are known also from dual posters of the Late La Tène type, for example at Soběsuky in Northwest Bohemia, while one six-poster from Strakonice in Southwest Bohemia contains a pure Late La Tène assemblage (cf. Fig. 135).[6] It might be that the six poster hut-type was first developed as a settlement element in North Bohemia, where square huts with more numerous wall posts are already apparent in the Middle La Tène period. Likewise in Moravia, "Germanic pottery" with faceted rims and high-footed bowls of the Plaňany-type are known at many Late La Tène settlement sites, for example at Rýmice, Pravčice,

3 Cf. Almgren 1923, Tejral 1992

4. Venclová 1973

5 Peškář 1961

6 P. Holodňák of the Žatec Regional Museum pers. comm., 1993, cf. Michalek 1990, Waldhauser 1994

Koutec near Štramberk, Břest, Kolicín, Bořitov, Staré Hradisko and Vyškov (Fig. 136). Thus, a simplistic equation of settlement forms and material culture with ethnicity cannot account for all material transforms witnessed at the interface of the pre-Roman and Roman Iron Ages.

In addition to such six-posters, Early Roman Iron Age settlements also contain modest storage pits, clay pits, occasional superficial post-hole structures and iron-smelting pits. Late Roman Iron Age settlement features are simpler, with six-posters being replaced by square half-sunken-huts with corner stake-holes, often found as isolated features in larger-scale excavations such as those at Závist in Central Bohemia and Štúrovo in South Slovakia.[7]

Early Roman settlement features occur in hamlets and small villages, although these are rarely excavated to a significant degree. Two exceptions to this rule come from Moravia, from Vyškov and Křepice. The site of the Vyškov in Central Moravia is assigned to the later part (2) of the Eggers B stage, a duration of perhaps two to four generations. Within this period, a group of nine six-poster huts, two superficial post structures and 17 storage pits are established within 0.4 hectares, an area representing between one sixth and one quarter of the total site area (Fig. 138). Population estimates of the Vyškov site will depend then on the presumed duration of occupation and the proportion of the site excavated. With respect to the former, cross-cutting relationships at the site are represented by a single storage pit cut into the side of a six poster, suggestive of at least two phases of occupation, however the position of most domiciles is mutually respective. With respect to the latter factor, a notion of site extent (2.4 hectares) could be garnered from the extent of surface sherds. Within these limits, a site population of 55 to 135 might be estimated.[8] Similarly at Křepice in South Moravia (not to be confused with the Eneolithic site), the occupation immediately prior to the Marcomannic Wars (late Eggers B2, a period of one-to-two generations) consisted of 13 six-posters, for a (max.) site population of 65. Later occupation at the site contemporary to the conflict with Rome (Eggers B2/C1) consisted of only three huts.[9]

Significantly, fortified sites are unknown from the Roman Iron Age, although the isolated Oppidum of Třísov continues to be occupied until the end of the 1st century BC. Much later (5th Century AD) hill-fort occupation is recorded at Rajhradice near Brno, where a promontory is

7 Cf. Tejràl 1990

8 Cf. Šedo 1991

9 Droberjar 1994

protected by three parallel ditches.[10] The Early Migration period reoccupation at Závist near Prague might also be defensive, given the natural protection afforded by that rugged place.

Transforms of micro-regional agricultural settlement structure

On a micro-regional scale, the settlement archaeological investigations of M. Kuna at Vinoř near Prague is informative as to agrarian settlement structure (Fig. 10). Like earlier periods, settlements and places of minor finds are clustered together into distinct local groups at Vinoř, however this tendency is more pronounced in the Roman Iron Age, when such clusters can include more than a dozen sites. Also unlike previous late prehistoric patterns, the local group clusters of the Roman Iron Age are more widely spaced from one-another, with five km being an average of this respective distance. Furthermore, the respective distance in each case is defined not on the basis of the fluvial dendritic network, but rather on the basis of inter-fluvial distance.[11]

The micro-regional importance of interfluves may recall aspects of the Germania of Tacitus, who comments on the greater pastoral orientation of the Germanic tribes, to whom inter-fluvial pasture as well as prime arable land would be held at a premium. Philologically, the Early Germanic agricultural vocabulary is also indicative of a micro-mobility of agrarian settlement, with words such as "hurst", "thwaite" and "rade" referring to rotational clearings by burning, as well as the replacement of the evocative "domus" term by the merely locational "haus".[12]

Ecological controls on Roman settlement structure

On a macro-regional scale, further fundamental changes are observable as settlement density declines and Early Roman optimal climes give way to cooler agro-climatic conditions. With respect to chronological variation, the number of settlement sites declines significantly from Early to Late Roman Iron Age times. In Bohemia, the number of find-spots of all categories declines from 228 to 142 during the early to late periods. This change is also accompanied by a reduced density of intra-site features in Late Roman times, in tandem with the end of the Early

10 "Archeologie z Ptáci Perspektivy" (exhibition at the Technical Museum in Brno, Spring 1994)

11 M. Kuna pers. comm., 1993, cf. also Kuna 1991

12 Markey 1989 Also on the basis of Lange's (1971) findings from settlements of the Germanic period in East Germany, a notably high proportion of pastoral weeds and relatively low cereal pollen is encountered.

Roman agro-climatic maximum.[13] Similar tendencies are also observable in Moravia, where the great majority of domestic finds from trans-Roman sites derive from Early Roman times.

An ecologically determined settlement dynamic is discernible in South Moravia, in that Late Roman settlement is practically never established below the 200 m contour, an indication of the sensitivity of the dry-agricultural regime to potential moisture deficits in low-lying steppe areas.[14] In North-Central Europe, an analogous shift of settlement away from the poor acidic soils of north Poland to the löss-lands of Little Poland and Silesia is observable between Early and Late Przeworsk times.[15] Meanwhile in East Slovakia, there is also reorientation of "Dacian" sites in the Košice lowlands onto the foothills of the Tatras.[16] These events might be understood as adaptive adjustments to increased climatic continentality brought about through reduced Atlantic air mass penetration or depressed summer-time anti-cyclonic activity with generally weaker atmospheric circulatory patterns associated with some climatic minima.

Smaller, Late Roman Iron Age settlements usually consist of only one or two houses, for example at Zaluží in Central Bohemia, where a single house with six posts was found.[17] More closely-related to Migration period house constructions is a structure with four corner posts from Zliv in South Bohemia,[18] a type also found at Štúrovo in South Slovakia, where three Late Roman huts with clay floors of up to 20 m^2 in area occur.[19] In Moravia, only isolated houses are known from the relatively extensive excavations at Bořitov and Brno-Obřany, although four such structures have been recovered from Mušov in South Moravia (cf. Figs. 139-140).[20] Smaller settlements might thus reflect the net effects of less optimal agro-climatic conditions.

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13 Motýková-Sneiderová 1963, 1967

14 Pernička 1964

15 Godłowski 1984, Domanski 1994

16 Budinský-Krička and Lamiová-Schmeidlová 1990

17 Motýková-Sneiderová 1960. Notably, a Late Przeworsk site at Niedwiednik in Upper Silesia produces four domiciles and three storage pits within an area of only 210 m^2, in which ceramics, loom-weights and spindle-whorls are found (Kowalska 1992).

18 Zavrel 1989

19 Kaltöfen 1984

20 Tejral 1990

Cemeteries and social conditions of the Roman Iron Age

The funerary rite if the Roman Iron Age is simple, and consists of cremation burials with urn, although a minority of inhumations are also known. A renewed tendency to intern the dead in cremation pits with urn had already emerged in Late La Tène times. The quantity of burial evidence also increases markedly in the Early Roman period, when long lasting cemeteries such as Třebusice are known with more than 800 graves Even the richest of these Early Roman burials are more simply equipped than the modal range of burials of the warrior class of the Middle La Tène flat inhumation cemeteries.[21]

Exceptionally, a most remarkable grave of the Earliest Roman Iron Age (Eggers B1a) comes from Prague Bubeneč, where a chamber containing a single inhumation is found with an imported Roman drinks set, perhaps the grave of a client-king? Although the majority of ceramic and metallic finds are of "native" types, finds of Terminal La Tène derivation include a wheel-turned graphite urn. Also given Classical references to a Gothic presence at the "court" of Moraboduus, a triple set of Gothic eye fibulae is also of interest.[22] Perhaps this artifact set reflects the wider socio-cultural contacts of leading members of barbarian society.

Although of larger size than the flat cemeteries of the Middle La Tène, the bi-ritual cemeteries of the Roman Iron Age contain far fewer weapons. Armed with spears, only three weaponry graves (49, 71 and 96) were found in the 104 Early Roman internments at Tišice.[23] Much rarer are sword graves, which are generally also accompanied by a lance, for example from Lebešice in Bohemia. By Late Roman Iron Age times, weaponry finds become rarer still.[24]

In Moravia, Late Roman Iron Age cemeteries have been excavated in their entirety from Kostolec na Hané and Šaratice near Slavkov. The former cemetery of 437 graves is significant also in that the entire mortuary assemblage (deposited over six human generations, or about 70 to 80 + internments per generation) is of Elbe Germanic (Langobardic?) cultural affiliation. Like contemporary Bohemian cemeteries, weaponry is relatively rare, with only 10 warrior graves

21 Motýková-Sneiderová 1963

22 Novotný 1955

23 Motýková-Sneiderová 1963

24 Motýková-Sneiderová 1967

known from Kostolec (or ca. 2.5% of the grave total).[25] Also at Late Roman Šaratice, of 163 cremation graves, only one (Grave 150) contains an iron spear and shield fittings.[26]

Of Roman Iron Age cemeteries in West Slovakia, that at Abrahám is the best excavated. The site is on a loess terrace of the Černá Voda. Consisting of 237 bi-ritual graves altogether, stray finds include weapons such as the Germanic *angon* (a small javelin) as well as a Roman *pilum*, which might have been taken as booty from a Roman engagement.[27] Early discoveries include eleven graves, one of which (Grave F, with a female internment) contains gold rings, bronze fibulae, an iron knife and terra-cotta spindle whorls. A second rich grave (G, of warrior aspect) also contained an iron spear. The 226 graves investigated subsequently, at least fourteen simple spear graves are recorded, as well as one grave (131) with sword and shield and one (205) with spear, sword and shield. Uniquely, a further grave (156) also contains inter-locking iron ringlets of ring-mail armour. Unusually, 14% of the recovered graves from this cemetery can be assigned to the "warrior" class, possibly reflecting special social conditions of the Marcomannic War period.

From the viewpoint of Roman "collaborators", the material rewards to be garnered thus are expressed in the "Königsgrab" from Mušov in South Moravia.[28] Dated to the Eggers B2/C1 stage of the Roman Iron Age, the grave is coeval with the period of the Marcomannic Wars. Set in a stone-lined chamber 6 x 4 m in area, two cremations placed within were accompanied by 150 artifacts in gold, silver, bronze, iron and clay. The ceramic inventory consists of native types. Gold and silver finds include twelve riding spurs of an ornate type (as well as four more practical Przeworsk spurs in iron. Small belt and bridle ornaments are also included amongst the Ädelmetal, for example small pyramid-shaped bridle ornaments of a North Pontic Czernjachov Culture type, as well as two circular plate brooches bearing triple tamgatic symbols of a kind common to the pastoral-nomadic Sarmatians.[29] The iron lance placed alongside the dead also bore such tamgatic signs. Furthermore, an iron fire dog points towards more Gallic cultural traditions, while eight bronze vessels are derived from Italic workshops. One bronze vessel of particular note is adorned along its rim by four portrait heads (all identical) which wear hair with

25 Zeman 1961

26 Trnáčková 1960

27 See Kolník 1980, Plate LXVIII, 18

28 Peška et al. 1991, Tejral 1992, 1994b, 1994c

29 Cf. Sulimirski 1970

a "Suebic knot" and a long beard (Fig. 137). The likeness rendered may be that of a Suebic client-king whose grave location amidst Roman marching camps is not coincidental.[30]

Roman military archaeology of Moravia and Slovakia

Meanwhile in Rome, in AD 175, a column is built in honour of the exploits of Marcus Aurelius among the *Barbari Superiores*. Portrayed are lines of barbarian prisoners being led to their execution, while woman and children are led away into slavery. The same story is told on the stele of Aelius Septimus of Brigetio in Pannonia (of the unit intercepting Ballomar's force), portrayed in the act of executing hapless prisoners.[31] These hostile legionary activities in Moravia and Slovakia are borne-out in the archaeology of Roman marching camps.

Beyond long-established military stations directly on the *limes*, Roman military dispositions in the Czech and Slovak Republics are known mostly within 20 km of the Middle Danubian frontier. Two site concentrations have been subjected to recent research, that at Iža in Southwest Slovakia, and that at Mušov in South Moravia. Firstly, the main camp of Iža on the far bank of the Danube is the base of a cavalry unit. Of two main phases, the first camp was built of timber, which numismatic evidence suggests was burnt-down in AD 179, two years after the termination of the initial truce of Aurelius. The subsequent camp built of stone is reestablished quickly, with a *denarius* dating this phase to AD 180-183, at the end of the Marcomannic Wars.[32] Further marching camps in the region of Iža have been subjected to recent study, for example at Radvaň nad Dunajom and Můžla Jurský Chlum (cf. Fig. 69).

A second concentration of finds around Mušov in South Moravia was first investigated by Gnirs, where the site of Burgstall produced finds of a stone hut (equipped with a *hypocaust*) as well as numerous well-made bricks bearing stamps of the Tenth and Thirteenth Legions (cf. Fig. 64). Military artifacts include boot-nails, fragments of weaponry and a shoulder piece of *loricum squamata* bearing the (genitive) inscription *Bruti* (of Brutus), a Senatorial nobleman on campaign with Aurelius. Both infantry and cavalry panoply occur, while the site periphery also produces evidence for fortification, terminating after five coin finds in the year AD 173, just

30 Cf. Bouzek 1994

31 Cf. Kolník 1984

32 Kuzmová and Rajtár 1986

before the Aurelian truce.[33] In respect of the graphic representations of mass executions on the Aurelian victory column, salvage finds from below Burgstall support their reality, where-in excavations of a section of a fortification ditch have produced skeletal material including 40+ individuals (of women, children and old adult males after preliminary determinations).[34] It is probable that this non-combatant group had been put to death by the Romans.

Agriculture in the Roman Iron Age

Macro-botanical finds from the Roman Iron Age attest to the final replacement of emmer wheat as a major crop, as rye, oats and barley come to be the primary cultigens. Some regional variation to this pattern is apparent. Although barley is present at more than 50% of sampled sites in both Bohemia and Slovakia, oats are far more common in Bohemia (50%) relative to Slovakia (21%), while the presence of rye exhibits the inverse pattern, found at 10% and 57% of sampled sites respectively. Spelt wheat is still found in modest amounts in Slovakia, where millet also appears to be more common (42%) than in Bohemia (20%). A less intensive or more extensive agricultural regime might be inferred after lower incidence of nitrogen-fixing crops, which occur at (ca.) 10% of sites in Bohemia, and 11 to 16% of sites in Slovakia (i.e., about 20 to 25% of their Late Hallstatt levels). The contemporary crop assemblage in Poland is much like that of Slovakia.[35] Crops of future importance appear at this time, for example at Iža, finds of *Vitis vinifera* might reflect the proximity of both Roman legions and Pannonian vineyards. Of steppic derivation is *Cannabis sativa* from Nitra-Párovské Háje, which may have been first used aromatically by the pastoral nomads of the Northwest Carpathian Basin. Like the case of millet, is important to distinguish between larger, pure finds of later date and earlier sporadic finds when trying to establish early dates for regular cultivation. At present, early (Neolithic) finds of hemp do not meet this empirical standard, although it is suggestive that Neolithic finds of hemp in Central Europe are of natural origin, as this taxon thrives in warmer, drier climatic conditions (cf. Chapter 4). Like the analogous cases of rye, millet and spelt wheat, the case for Neolithic hemp cultivation must be considered as a possible, but not yet probable, hypothesis.[36]

33 J. Tejral pers. comm., Spring 1996

34 M. Bálek pers. comm., Spring 1994

35 Wasylikowa et al. 1991, Hajnalová 1989, 1990

36 Hajnalová 1993 The matter of early millet, rye, spelt wheat and hemp cultivation was discussed in detail with E. Hajnalová and K. Wasylikowa. The consensus of present opinion in this community is critical of this hypothesis.

Population dynamics of the Roman Iron Age

The Roman Iron Age populations of Bohemia, Moravia and Slovakia appear to have reverted to an age-old pattern of small village-based low-lying settlement without recognisable geographic nodes of control. Given settlement population estimates ranging between 65 and 135 inhabitants, and a minimal (mean) mortuary population of 80 at Kostolec na Hané, it would appear that local groups are fissioning below a 150 inhabitant threshold (cf. Chapter 2). Despite a lack of settlement hierarchy, the ability of tribal groups from these same territories to muster war bands in the lower thousands cannot be doubted. Even if Cassius Dio's estimate of 6,000 warriors and ten kings led by Ballomar should be an exaggeration in the order of 100%, at least 3,000 warriors led by 11 leaders are to be reckoned with, or an average of (ca.) 275 warriors per war band. Even if such a force comprised most of the adult males from a hypothetical tribal community, they can scarcely have represented more than 20% of that community, implying a hypothetical regional population of about 1400 per segment.[37]

The population level of such a tribal segment would encompass at least 12 community areas of Kuna at Vinořský potok, based on liberal population estimates for individual villages after Vyškov. Given the radial circumspection of Roman community areas, a rough estimate of the size of a tribal range can be made: (ca.) 240 km^2 of prime farmland. Suggestively, this land area is also very close to the minimal scope of the population catchment (under 350 m. a.m.s.l.) proposed as a demographic basis for the formation of the Late La Tène macro-sites.

Respecting the ethnic composition of the Roman Iron Age tribes, it seems unlikely that these are of a simple Germanic composition, should the prior presence of Galatian tribes such as the Boii be taken at face value. The broad transformations in material cultural following the La Tène Iron Age, rather than being viewed in terms of population replacement, should rather be viewed with respect to the fact that cultures do undergo changes of state, most-likely as a result of a complex of factors including not only extrinsic population infiltration, but also intrinsic social transformation. Rather than a simple ethnic replacement then, the northern affiliations of Roman Iron Age material culture might be taken as an indication of the transformation of the social and tribal structures which "iso-morphise" with those of northern tribes.[38]

Certainly, the list of tribal names provided by Strabo cannot all be attributed to "Germanic

37 Cf. Czarnecka 1990

38 With primary population infiltration and secondary culture trait adoption, stemming from the northern culture zone.

tribes" in the strict sense, as East Germanic Goths are also mentioned. Links between Gothics and Slavonics are furthermore suggested by Gothic loan words such as sword ("mienk", Polish "miecz"), armed guard, court or fortified place ("gards", Old Slavonic "gorod", cf. Celtic "gurd"),[39] bread ("hlieb", Czech "chleb") and the Gothic attribution of alpha-stem masculine nouns (significantly, these relate only to social status terms ranging from warrior to slave).[40]

Evolution of Roman Iron Age agricultural society

In terms of ecological adaptation, a degree of micro-geographical variation is evident in the settlement of Bohemia, Moravia and Slovakia. In Bohemia, the land areas occupied are much the same as the preceding periods of prehistory, in other words, low-lying czernozems are preferred. The micro-geographical preference exhibited by the contemporary Moravian farmers betrays a greater concern for avoiding the driest areas (under 200 mamsl), while in Slovakia, low-lying areas such as Abrahám and Radvaň nad Dunajom are occupied, although in this case the arable agricultural exploitation of the Danubian inundation plain is expected.

Elements of nomadic material culture in agrarian settings are indicative of a secondary culture trait adoption by chiefs of the Marcomanni and Qvadi, of which Prague Bubeneč represents an early example. Further ambitions might have induced some chiefs to collaborate with the imperial system to the south, producing graves such as Mušov-Königsgrab in Moravia, and perhaps Stráže in Slovakia.[41] Not unlike the situation in the Late Bronze Age urnfields, the proportion of warrior graves is low (<2.5%), unless modified by special conditions imposed by the Roman invasion (e.g. at Abrahám). It would appear on this basis that a more restrictive attribution of Roman warrior status was practised than was the case during the Middle La Tène. Is this direct evidence of a chiefly social structure amongst the Germanic tribes?

In contrast to the macro-settlements of the Late Iron Age, settlements of the Roman Iron Age also reflect a minimum of physical investment. Rather, defense and social cohesion are achieved through social means. The central role of these chiefs in the cohesive organisation of tribal society is thus reflected in Tacitus, who in Book 14 of Germania says of the chief's valour that "none in the tribe may surpass it, yet none in the tribe would suffer the death of his chief". The

39 de Vries 1960

40 Cf. Wright 1924

41 Tejral 1994c

Roman senator's words regarding the chiefly succession are also interesting, in that they imply the importance of lineage, without the devolution of chiefly power into a single lineage. In other words, multiple chiefly clan segments may be present within a given tribal aggregate.

Thus, exceptional rich graves such as those at Mušov-Königsgrab, Stráže and Prague Bubeneč might reflect in the funerary rite a specific social condition of Roman clientship among some border tribes, when the mass of burial evidence exhibits relative simplicity. There is simplicity also in the settlement record, which lacks clearly recognisable nodes of control. The less complex society succeeding from the Oppidum period might have thus achieved a better balance in the organisational efficiency of the economy and in the orientation against military threat. Ultimately, the more dispersed and a-nodal agricultural settlement of the Roman Iron Age Danubia proves to be more robust in the face of Roman invasion than the Oppidum-based system of Late La Tène Age Gaul.

In the wake of the Marcomannic Wars, the periodic settlement cycle is once more in evidence, with an increasing paucity of settlement remains developing with the approach of the Migration period. Not only in *Barbaricum*, but also in some European provinces of the the Roman Empire, an agricultural crisis is recorded both in historical and geo-botanical sources.[42]

With a decrease in population density, the tribal population mobility attested during the Migration period might be seen as an adjustment to a resultant "settlement vacuum", instability further encouraged by the disintegration of the Roman Empire and the complex socio-political patterns of Romano-Germanic elite reintegration into the Early Dark Age Kingdoms.[43]

Review of settlement archaeology and primary geo-botany

Reconstructions of settlement site demography throughout the Roman and Migration periods depends entirely on domestic finds in the strict sense. In the early period, these domiciles consist half-sunken huts with six wall posts, although more variable forms of half-sunken huts appear in the later sequence. Like huts of the La Tène Iron Age, half-sunken huts of the Roman period are dug to a depth of (ca.) 30 cm. Only sites less-subject to erosion are thus suitable for population reconstruction for these periods.

Dense, micro-regional clusters of Roman Iron Age settlements identified by Kuna at Vinořský

42 Cf. Zabehlický 1994

43 Cf. Poulik 1949, Tejral 1973, 1990b

potok seem to have palynological analogs at Vranský potok, where Early Roman primary cultivation values of 6.5% (the highest in pre- or proto-history) are reached. These values subsequently decline to only 1.1% or less during the Late Roman and Migration periods, in-phase with the proto-historic settlement trend towards smaller, more dispersed settlement sites.

From Pannonia, a suite of four archaeological pollen sites at Mušov-Burgstall, V Pískách, Radvaň nad Dunajom and Můžla Jurský Chlm reflects a profoundly destructive Roman influence on local vegetation, with the cutting of riparian woodlands and the promotion of a more xeric, salt-tolerant community of floral species on a local to micro-regional basis in the northwestern periphery of the Pannonian steppe.

Pollen spectra from these Roman marching camps of the Marcomannic Wars furthermore attest to the complete elimination of local Germanic agriculture which accords with Dio's commentary on the attritional strategy employed by Marcus Aurelius towards the reduction of the Middle Danubian Germanic tribes. A lack of primary indicators is evident then in spite of the local presence of native settlements, which are presumably evacuated during the periods of intermittent Roman occupation.

13. Methods of archaeologic and ethno-historic modeling of tribal demography

Different methods of palaeo-demographic reconstruction employed on a periodic basis in Chapters 9-12 after Central European settlement archaeology of later prehistory are now reviewed. Following from a local negation of the Behaviouralist hypothesis in Chapter 6, a negation of a general Behaviouralist hypothesis as an explanation for the settlement cycle is also indicated in a comparison of sunken feature depths and forms through time. Employed as a "currency" of settlement density, diachronic comparative sherd densities are also derived from sites of the Late Bronze to Late Iron Age, affirming sub-surface feature to domicile ratios used throughout these periods.

As explicated in Chapter 3 and tested in Table 6.3, independent geo-botanical lines of evidence have been employed to see if indeed sherd densities <u>on average</u> reflect agricultural settlement intensity. Of course, it possible as well as pertinent to posit that intervening variables of deposition strategies are <u>always</u> at work in the production of the settlement archaeological record.[1] The point made in the primary data presentation of this work would appear to be that such intervening variables comprise only a minority component in the production of the total <u>settlement</u> record, although structured deposition may be a predominant characteristic of <u>funerary</u> and "cultic" sites. However, in addition to purely independent (primary geo-botanical) lines of evidence, less independent but still suggestive variant comparative data patterns of artifact-feature-settlement site composition are also examined in this chapter (as culled from published secondary material) to justify Eneolithic to Early Bronze Age population reconstructions employed in Chapters 9-12. These latter data patterns negate the presumption of M. Kuna that differential settlement site feature densities are a by-product of erosion of differential feature depths. Actual histories of discoveries of features from minimal settlement periods suggest rather that <u>initial</u> feature <u>dispersion</u> is a major differential factor in settlement site data recovery.

In the final part of this chapter, the use of Greco-Roman (Classical) "ethno-historic" sources is justified. These written sources, if used judiciously, reflect upon aspects of proto-historic tribal organisation on the southern limits of Central Europe. Key aspects to be considered in these Classical works include the population scale of tribal-martial potential, and secondarily, the implied scale of socio-political integration which follows from ethno-historic observations of boreal tribal conflicts with Classical civilisation. The analytic time-span of documentary consideration includes only the Middle to Late La Tène and Early Roman Iron Age.

1 E.g. Chapman 1999

Comparative profiles of sunken features employed in site population reconstruction

Given the observation that archaeological features will not be detectable unless they are dug to a level deeper than net erosion, it has been proposed that periods of slight settlement traces are products of differences in feature digging behaviours, whereby the prehistoric digging of shallow features is correlated with a scarcity of settlement remains at flat sites. Of course, tell-like sites reflect a net anthropogenic accumulation of settlement debris which is positively correlated with intensive settlement beyond the scope of the (flat site) Behaviouralist hypothesis as set forth by Neustupný and Kuna.[2] In order to account for the perceived later prehistoric settlement cycle, these behavioural changes must also be expressed as cultural norms which are temporally variant on a regular secular time-scale. Consider the regularities of feature depths as preserved on flat sites and the periodicity of tell-like accumulation:

Table 13.1. Feature depths at flat sites, tell-like accumulations and settlement intensity

Period	*Sunken feature depths in cm (sites)*	*Pannonian tell-like sites*	*Settlement intensity*
Early Eneolithic	ca. 80 (storage pits, Prague-Baba)	beginning in Baalberg B1b	min. (tells greater)
Middle Eneolithic	ca. 30-40 (midden pits, Homolka)	at max. Eneolithic accum.	max.
Late Eneolithic	ca. 20-60 (midden pits, various sites)[3]	minimal tell accumulation	min.
Early Bronze Age	ca. 40-120 (var. pits, Březno, Mušov)	at max. Bronze Age accum.	max.
Tumulus Culture	ca. 40-80 (var. pits, H. Počaply, Vochov)	accumulation ceases	min. (B.A. B2-C1)
Urnfield period	ca. 120 (stor. pits, Březno, Lovčičky)		max.
Hallstatt C	ca. 30-210 (circular and rectilinear pits, Vikletice, Chotěbudice)		min.
Hallstatt D	ca. 30-200 (cir. and rect. pits, Kuřim, Pohořelice)		max.
La Tène period	ca. 30 (half-sunken huts [twin posts], various sites)		min. to max.
Early Roman	ca. 30 (h.-sunken huts [six posts], Vyškov, Mušov, Křepice)		max.
Late Roman	ca. 30 (h.-sunken huts[variable no. of posts], Křepice, Lovčičky)		min.

2 E. Neustupný and M. Kuna pers. com., various occasions. This hypothesis is implicit in the research methodologies of these authors although it remains inexplicit in most works save Neustupný 1969. The above authors have never constructed an explicit test of assumptions regarding the structuring of settlement archaeological evidence, this work attempts such a test.

3 After Vencl (1994), Šebela (n.d.), Pavúk (1981b) for the Corded Ware and Chlopice-Veselé cultures, and Hájek (1968), Dvořák (1992) and Točík (1961) for the Bell Beaker and Kosihy-Čaka periods of Bohemia, Moravia and Slovakia respectively.

During the Eneolithic, little or no correlation exists between perceived settlement intensity and the relative depth of settlement features. However, the middle period of greatest (flat site) settlement intensity is coeval with the period of greatest tell-like sediment accumulation. Alternatively, problems of site identification of the Eneolithic epoch may be more contingent upon the quality of settlement pottery, which is often lacking in diagnostic features (Fig. 79). This poverty of decorative attributes also makes the reconstruction of vessel forms difficult in practice. Thus at Prague-Baba, the recovery of (ca.) 40,000 artifacts is not sufficient to place the occupation within specific sub-phases of the long duration of the Funnel Beaker Culture, in which only 21 vessels are reconstructed, including one bowl of the Channeled Ware Culture. As observed in Chapter 9, the cultural designation of Eneolithic sites can be problematic, and sometimes follows from the identification of individual pottery sherds. Anecdotally then, one culture pit of Channeled Ware date excavated by M. Geisler at Pohořelice in 1994 contained only a single sherd bearing channeled decoration, while the technological attributes of the remaining settlement pottery might have placed these (ca.) 50 sherds into any period between the Early Eneolithic and Early Bronze Age. Similarly, possible Bohemian Corded Ware settlement sites cited by Vencl are tentatively identified on the basis of small numbers of diagnostic sherds in midden pits with a larger mass of undiagnostic settlement pottery. Importantly, these potential Corded Ware features occur as relative isolates in multi-cultural sites. Eneolithic pottery may also be difficult to identify from surface distributions, after field-walking data from Vranský potok. Within the basin, this period produces only a single sherd by the occupation at Hradiště. This poverty of surface pottery finds contrasts with a relative density of excavated find-spots above the first terrace as detected by the able A. Knor (cf. Fig. 38).

A correlation between settlement feature depth and settlement intensity may be observed in the use of storage or midden pits in demographic reconstructions of the Bronze Age epoch, in that Middle Bronze Age settlement features are of more modest dimensions. For example at Vochov in Southwest Bohemia, four settlement pits of (ca.) 40-80 cm depth accompany a post-built domicile preserved under a burial tumulus (Mound 1) of the Tumulus Culture; however, given that sub-surface to surface domicile ratios of (ca.) 4:1 have been proposed for the Early and Late Bronze Age, this Middle Bronze Age ratio is conformable to the general Bronze Age pattern.[4] Significantly, maximum tell-like accumulation occurs during the flat site settlement maximum of the Early Bronze Age, demi-tells which are entirely abandoned during the Middle Bronze Age.

4 Cf. Militký n.d.

In the light of the latter pattern, it still seems likely that the general Bronze Age settlement historical trajectory of a middle period minimum is real, in which Tumulus Culture settlement features also always occur as relative isolates in multi-cultural sites or in burial loci.

In the Hallstatt Iron Age, a relative uniformity of settlement feature depth and type can be observed (cf. also profiles of Feature 11 [Hallstatt C2] and Feature 10 [Late Hallstatt] at Vinoř). Once again, Earliest (Hallstatt C) Iron Age settlement features always occur as relative isolates in multi-cultural or mortuary sites. It would appear then that relative feature density rather than dimensional variance of features is primarily responsible for the differential archaeological recovery of settlements. The same observation may be made with respect to site demographic reconstructions for the La Tène and Roman Iron Ages, when half-sunken huts (with 2-6 support posts) of relatively uniform (shallow) depth are employed towards the estimation of site populations. Also, during the Migration period, it is suspicious that house isolates derive from sites such as Štúrovo, Lovčičky and Závist, where extensive excavation has focused upon the Neolithic, Bronze Age and La Tène occupations. One suspects that periodic settlement dispersion makes a systematic recovery of contemporary sites a practical impossibility. Settlement dispersion cannot be regarded as an independent variable, as such dispersal will be positively correlated with lower population densities, as well as disruptions of socio-political modes of control (importantly, cf. Table 2.1). In this way, the settlement collapse perceived at the terminus of the Urnfield period in Danubia might be a product of socio-political as well as environmental transforms. Inferentially, it is also interesting that more segmentary modes of socio-political control proposed for the Lusatian cultural zone during the Urnfield period are accompanied by a lower degree of settlement discontinuity at the Hallstatt B-C interface. Even within the intinsic empirical limits of testing archaeological data by means of archaeological data, the above data pattern may be said to negate untested assumptions of the Behaviouralist hypothesis elucidated by Neustupny and Kuna, namely, that variations in settlement densities are simply a product of a differential establishment of sub-surface feature depths as will be encountered at later prehistoric settlements.

An independent, extra-archaeological geo-botanical negation of untested assumptions of the general Behaviouralist hypothesis will also be presented in Chapter 14, based on primary pollen data of the author and secondary pollen and geological data where the former data base is insufficient towards that task.

Pottery sherd density data and affirmation of sub-surface feature to domicile ratios

Specific ratios of sub-surface feature to domicile reconstruction employed by the author can be justified after observed quantities of settlement pottery recovered per reconstructed contemporary household (cf. Fig. 141). It is desirable to verify such ratios, because sub-surface features are uniformly more robust and discernible under sub-optimal conditions of site erosion and excavation than are superficial post-built domiciles. The methodology used is empirical. First, sites where all classes of features are well preserved and carefully documented are employed to derive ratios of observed sub-surface features to observed domiciles (usually post-houses, sometimes also defined by clay floors at tell-like sites). These ratios are then used for demographic reconstruction at sites where the volume of excavation is greatest and chronometric control is best. Sometimes, the resultant ratio is applied to the same site at which this is derived, for example at Homolka, where presumptive hut units recognised in the central eroded part of the site are reconstructed after observations made in the intact perimeter. Assuming then that pottery sherds reflect a currency of settlement intensity where excavation and collection techniques are broadly similar, ratios of sunken features to domiciles should bear an inverse relationship to observed sherd quantities per feature. For the Late Bronze to Late Iron Age periods, these relationships are expressed periodically as follows:

Table 13.2. Product-relationships between household reconstruction ratios and sherd densities

Period	*A. Sunken features:domiciles (sites)*	*B. Sherd densities (sites)*	*(A x B)*
1. Early Urnfield	4:1 (Lovčičky, Liptice)	75/feature (Březno)	300/household
2. Late Hallstatt	2:1 (Kuřim, Sereď, Želenice)	177/feature (Jenštejn)	354/household
3. La Tène Iron Age	1:1 (various sites, cf. Fig. 141)	418/feature (N.W. Bohemia)[5]	418/household

Relative sherd densities per household-generation are thus broadly similar (300-418) after applying the observed ratios (A) above. Affirmatively, storage pit volumes are inversely proportional to changes in the Period 1-2 household reconstruction ratios. For example, the

5 Salač 1995. Note that Salač recognises a degree (+/- 50%) of inter-regional variability in contemporary Iron Age sherd densities between the Bílina and Middle Ohře valleys. The diachronic values assessed as comparable in this chapter fall within this range.

(Kuřim) 2:1 ratio is first employed at Hallstatt B Štítary phase sites which have storage pits of (ca.) 2 m^3 volume (assumes one domicile per storage pit and rectilinear sunken feature), while Knovíz sites (employing a 4:1 ratio) have storage pits of (ca.) 1.2 m^3 volume.[6] Effectively, La Tène and proto-historic half-sunken huts reflect a 1:1 household reconstruction ratio. Deep storage pits are largely lacking during this latter period, although more varied house constructions may be observed at upland Oppidum macro-sites. In the latter case, general population densities of 100/hectare are employed after Waldhauser. Confidence in this method is enhanced when considering the density of rotary quern finds (95/hectare) and half-sunken huts (49/hectare) on the Oppidum of Staré Hradisko. An identical population density is proposed (notionally) for lowland Lovosice sites, although investigations of such sites has been insufficient to provide quantitative support of such. Impressions garnered from recent salvage excavations of sections at Lovosice are suggestive of intensive occupation, however.

Importantly, independent palaeo-environmental verification of the Period 2 (Kuřim) ratio may be sought in the Late Hallstatt example of Vinoř, where palynology indicates that minimally (ca.) 20 hectares were under active cultivation (not in fallow) within a 0.5 km radius of the site, enough arable land to support a population of more than 100 inhabitants. It is also likely that most of the land within 1.0 km of Late Hallstatt settlement in the basin is deforested. After the minimalist micro-regional population estimates of Dresslerová, the loci of such sites are reconstructed to contain pasture and secondary woodland, after the economic needs of a much smaller population (Fig. 142).[7] The proposed arable potential at Vinoř closely conforms with the author's own reconstruction of the Late Hallstatt Jenštejn population within the same valley (see Table 11.1).

It might also be inferred that a general later prehistoric rate of recoverable settlement pottery deposition may be set within a range of (ca.) 12-16 sherds per household per year of occupation. Should this derived rate be retroactively extrapolated towards possible Corded Ware occupation sites, the implication is that these potential Late Eneolithic settlements represent only family isolates occupying individual sites for less than a human generation. In this light, it is significant that individual Middle Eneolithic sherd densities at identified hut units at Homolka range between 200-600, with higher densities being associated with huts occupied for more than

6 Turková and Kuna 1987

7 Cf. Dresslerová 1995a, 1995b

one sub-phase at the site (e.g., Hut C).[8] This Middle Eneolithic range also approximates sherd densities per household generation of occupation during later later prehistory (cf. Table 13.2 above), once the variable duration of hut occupation is taken into account.

Sherd densities per settlement feature from the Early Bronze Age interval might also be of interest, although this statistic is difficult to extract from the data base of Nitriansky Hrádok in that the analysis of pottery finds at this extensively excavated settlement is expressed largely in terms of fully reconstructable pottery vessels (usually comprised of 20-40 sherds) rather than individual pottery sherds. A (ca.) 4:1 household reconstruction ratio can also be derived here, and most storage pits approximate those of the Knovíz Culture in volume (cf. Features 205, 206 and 229 at Nitriansky Hrádok). Two (of 341) storage pits are inordinately large, however, and average 90 m^3 in volume (i.e., a volume equal to 75 typical storage pits, cf. Figs. 143-144). Their potential role as central grain silos in a redistributional political economy is suggested in the light of wider evidence for emergent regional polities in Early Bronze Age Pannonia.

These pits (Features 3 and 300) also contain in tandem some 299 reconstructable pottery vessels, or a total of some 6,000-12,000 pottery sherds prior to reconstruction. Conformably, a density of 33-67 sherds/m^3 can be derived from this substantial sample, or 40-80 sherds/1.2 m^3 (or the volume of Knovíz Culture storage pits, cf. Table 13.2 above, esp. Period 1 sherd density data from Březno). From this derivative range of sherd densities adjusted according to typical storage pits volumes, an observed 4.25:1 ratio of domiciles to storage pits is indicative of a generalised density range of (ca.) 170-340 pottery sherds per household-generation for the Early Bronze Age Mad'arovce Culture occupation, a range quite similar to the that indicated in Table 13.2 (A x B) above (cf. Note 3).

The tel site of Nitriansky Hrádok in Southwest Slovakia has also been employed as a check on estimated accumulation rates of Eneolithic tel-like sites in South Moravia, where-in an accumulation rate of (ca.) 0.27 m^3 per person *per annum* has been tenuously derived from Grešlové Mýto and Jevišovice (cf. Table 9.1). From Early Bronze Age site population estimates at Nitriansky Hrádok, an accumulation rate of (ca.) 0.35 m^3 per person *per annum* has also been calculated for the Classical Mad'arovce Culture occupation. The comparability of these two estimates is reassuring, although somewhat higher calculated rates of anthropogenic sediment accumulation at the Early Bronze Age site might follow from the use of more substantive house construction techniques (cf. Fig. 84) or from errors in site population

8 Ehrich and Pleslová-Štichová (1968)

calculation (i.e., either Eneolithic estimates are ca. 30% too high, or Bronze Age estimates are ca. 25% too low). Given the comparative demographic importance of Nitriansky Hrádok, further justification of its population estimate as modulated by the index of archaeological recover is now given (*a r*, see Chapter 2).

In most respects, the population estimate of the Classical Mad'arovce occupation at Nitriansky Hrádok is conservative. A maximum period of occupation has been assumed, while the potential for multi-phase occupation of individual huts has been noted, but not employed in population reconstructions. Conversely, the employed index of archaeological recovery (*ar* = 0.5) of domiciles at Nitriansky Hrádok doubles the population estimates to be derived from total of fully-reconstructable houses (among the 36 huts associated specifically with the Classical occupation), in that (burned) domestic ovens with minimal (unburned) preserved clay flooring and post-moulds are used to infer the presence of domestic units. In actuality, fully- and partially-reconstructable houses present a range of preserved features. For example, the best-preserved huts like one in Sectors H/23-4 contains a domestic oven, an intact clay floor and a (ca.) 80% complete post-mould pattern. Better preserved huts include one from Sectors H/19-20 and CH/19, where a domestic oven, a partially eroded clay floor and a (ca.) 60% complete post-mould pattern are preserved. Huts with ovens and partial patterns with largely eroded clay floors are also common (e.g., from Sector G/20). Partial house plans with ovens, discontinuous post moulds and eroded clay floors are not included in the roster of recovered huts, for example one from Sectors G-H/21. Finally, domestic clay ovens within indeterminate feature patterns are preserved where erosion has reduced more friable settlement evidence (e.g., one from Sector G/24). The latter two classes are also not included in the formal roster of huts, although it seems certain that these represent merely a more poorly preserved aspect of a continuum of recoverable domestic units in an industrial-scale (partially mechanised) excavation (cf. Figs. 97-8). This latter evidence is thus employed in the reconstruction of houses at Nitriansky Hrádok.

Inferred later prehistoric population densities and the demography of prehistoric cemeteries

General population densities inferred for maximum settlement periods such as the Late Bronze Age and Late Hallstatt may be roughly calculated from the settlement structure of well investigated areas such as Únětický potok in Central and Kadaň (Hradec) in Northwest

Bohemia. In the immediate locus of the primary agricultural zones, regional polities are reconstructed to support populations of *circa* 1300 within regions of (ca.) 50 km^2, or (ca.) 26 persons/km^2. Inclusive of inter-fluves, this would imply a general lowland Bohemian population density during maximal prehistoric settlement phases of (ca.) 13 persons/km^2. This inferred level accords well with population densities of (ca.) 10+/km^2 derived by Braidwood for pre-urban (formative-level, i.e., village-level) agricultural societies, from both ethnographic and highly complete archaeological settlement data.[9] Conversely, minimalist Late Hallstatt population estimates after Dresserlová for micro-regions such as Vinořský potok translate into general population densities more typical of complex hunter-gather societies of less than one tenth the former density levels (and thus quite in non-agreement with the results of pollen analyses).

Respecting the minimalist view then, one must consider once again the influential work of Neustupný, whose analyses of cemeteries of Early Neolithic and Eneolithic date have been used to infer a long-term population trend whereby local settlement rarely surpasses the modest hamlet level (20-25 individuals per community area).[10] The Eneolithic figure has been extracted from the Corded Ware cemetery cluster at Vikletice in Northwest Bohemia (i.e., from a perceived settlement minimum phase). In general, this minimalist demographic tendency arbitrarily downgrades population levels during perceived settlement maxima while maximising the indicative value of limited settlement data from perceived minimal phases, so as to negate relative population differences between periods. Importantly, diachronic cemetery demographic analyses (after Neustupný) of the Piliny (Middle Bronze Age) to Kyjatice (Early Urnfield) periods by Furmánek in the Slovak Republic provide evidence for a much higher potential population growth ($r = 0.006$) during this transition from lesser to greater settlement density.[11] This higher population growth potential receives independent support in geo-botanical evidence for more intensive land-use during the Bronze Age, specifically in the form of flood-loam accumulation from extensive soil erosion. This process begins in earnest during the Classical Early Bronze Age in the Morava River valley after Havlíček, and then during the Knovíz Urnfield period in Bohemia after this work (e.g., see Vranský potok, Beta 82510).

Use of Classical sources with respect to later tribal warfare.

9 Butzer 1964. The term formative here refers to the hardly controversial proposition that later prehistoric agrarian communities often established hamlets and villages, this as an emprirical fact without a necessary reference to an arbitrary evolutionary scale. Known population densities of these with settlement data comprise a meaningful analog.

10 Neustupný 1983

11 Furmánek 1994

Proto-historic reconstructions of regional populations have depended in part upon Classical sources whose use must also be justified. In the light of settlement and other archaeological data, these written sources have been used to determine the military potential of Germanic, Galatian and pastoralist tribals, as well as their potential scale of socio-political integration.

An important source for the Early Roman period is Cassius Dio, whose account of Ballomar's invasion of AD 166 into Pannonia and Noricum is suggestive of a considerable marshaling capacity on the part of Germanic tribes. Six-thousand barbarians under Ballomar and ten tribal leaders are then defeated by a full legion (5,000+ troops) sent from Brigetio, after Dio. A potential inflation of barbarian numbers is allowed for, in that a down-graded body of 3,000 warriors is employed as a base-line for the extrapolation of total population of tribal segments. This conservatism follows from a tendency of Dio to exaggerate numbers involved in battles, for example, the "120,000" Iceni proposed for the East Anglian campaign of AD 60/1. These "twelve myriads" might reflect an "apologetic" for the defeat of the "unlucky" IX Legion in the campaign, as well as a <u>qualitative</u> use of the term "myriad" as per "host" rather than "10,000" in the strict sense. No "apologetic" need be expected respecting Ballomar's host, as these war bands are quickly defeated once intercepted. It should be noted that the proportion of the total tribal population represented in this latter force has been estimated after socio-mortuary patterns from coeval Przeworsk cemeteries in Poland, where warrior status is actively symbolised.[12]

Strabo's ethno-historic account (after much earlier observations of Poseidonios) of La Tène Age Galatians forms a less direct basis of understanding of Late Iron Age tribal society. The linear tribal model proposed (in Chapter 11) is not a new one, and has been criticised by some on insubstantial grounds.[13] None-the-less, the inference that Middle to Late La Tène Age populations were specifically integrated into segmentary linear tribal formations known to ethnography is not necessary to the main thesis. What should be recognised then is the latent potential of later tribal societies of limited logistical integrity to muster martial bodies from areas beyond their immediate reach of politico-economic adjudication. This impermanent military integration is probably achieved through spatially expansive social relations, whose presence is later suggested by numismatic evidence from the Oppidum period. Specifically, the repetition of identical leader names such as BIATEC on coins of distant and different Oppidum mints may reflect extensive kin-relations or shared social epynomical norms of leading Late La Tène clans.

12 Czarnecka 1990

13 Cf. Roymans 1990

It is possible then that hypothetical Middle La Tène linear tribal formations reflect a devolution of Urnfield-Hallstatt conical clans, for the latter kin-structures will parallel that of segmentary linear tribes, albeit with ranking between clan segments. This latent vertical ranking potential of (segmentary) linear kinship systems might then enhance a trajectory towards settlement hyper-agglomeration notable in the Oppidum period, given necessary linkages between political complexity and maximum settlement size (cf. Table 2.1).

During the Roman period, a potential for (secondary) political transformation of tribes in contact with the limits of the Empire must also be entertained, as the accounts of barbarian client-kings by Tacitus and Strabo have mortuary analogs in the graves of Prague-Bubeneč and Mušov-Königsgrab. Pre-Urnfield tribal political systems are potentially much simpler, with martial capacities restricted to the immediate locus of politico-economic adjudication.

Finally, the use of Plutarch's account of Carrhae (53 BC) must be justified, given its following (Chapter 14) employment in the calculation of a (1:4) coefficient of unmounted to mounted warrior effectiveness. This ratio of martial effectiveness will serve as the coefficient of direct competition in the application of the Lotka-Volterra matrix towards the resolution of an equilibrium outcome in tribal warfare between agrarian and pastoralist. The (infantry dominant) Roman order of battle at Carrhae is well established, while Plutarch's estimate of 11,000 Parthian cavalry accords with recorded cavalry bodies assembled into earlier Seleukid field armies, whose mounted troops were drawn from the same Iranian provinces as the Parthians. The 1:10 ratio of armoured (καταφρακτοι) to light horse in this Parthian cavalry body is also similar to to that of the (household) companion cavalry in Seleukid mounted troop lists in the time of Antiochus III.

In employing any derivative of the coefficient of direct competition to conflict situations, some attention must also be given to the question of fortification, which allows members of tribes of lower (integrated) population levels to deter larger bodies of attackers. This latter negative feed-back enables equilibrium conditions in the Lotka-Volterra outcome matrix to be achieved prior to the establishment of a feed-back loop leading to run-away political agglomeration, truncating any trajectory towards the formation larger political units when competition over limited natural resources arises. Such "competition" need not be absolute, for relative subsistence concerns, as well as culturally engendered factors may also provide a motive for tribal warfare (see below).

14. General conclusions

The dual empirical themes of this work are constituted by primary evidence for natural history and secondary evidence for cultural and settlement historical development in relation to the natural history of Central Europe. This dynamic relationship is expressed firstly as the circumspection of agricultural settlement by climate, soils and flora, and secondly as human impact on these soils and flora. Ultimately, should human impact be severe, a denudation of the environment may ensue, further circumscribing the natural limits of agrarian settlement.

The two historical variables directly considered are essentially flora and population in these natural and cultural historical frameworks respectively. In the first case, the flora which comprises the primary analytic framework also provide the basis of human population subsistence, within which context the reconstruction of palaeo-climate is also considered to be important due to the edaphic marginality of temperate climates to crops widely used in early agriculture in Central Europe. In the second case, population density (inferred after secondary studies of settlement sites) comprises a major factor determining levels of anthropogenic environmental impact, levels of intensity of agriculture and levels of socio-political integration.

Actively uniting these two empirical themes of vegetation and population then is the means of cultural adaptation to the environment. Principal analytical treatment of the adaptation concept focuses on somatic concerns, particularly agricultural subsistence and warfare. Reproductive adaptation is only implicitly addressed as subsumed under the population factor, as for example towards the spatial reconstruction of minimal tribal areas under given population densities and the derivation of minimal network areas of inter-regional elite-interaction as such ranked groups are transposed above the mass of the population with socio-political complexity. Perception of this transposed mating population construct depends in part on the reconstruction of ancient modes of socio-political organisation after settlement and mortuary data, although weak if independent support for the spatial extent of vertically transposed kin networks is inferred after geographic distribution patterns of elite sub-cultural artifact assemblages.

Of natural environment and human settlement, it is important first to outline the development of method in interpreting human impact in alluvial pollen settings. These levels and their indicative value vis à vis changes in palaeo-hydrology, deforestation and cultivation will be defined initially.

These levels of human impact will then be employed towards tests of the Behaviouralist and Climatic hypotheses, which seek to explain the structure of settlement archaeology in terms of mere differential visibility in the former, and a real culture-nature dynamic in the latter case.

Later prehistoric population and tests of the Behaviouralist , Climatic and Carneiro hypotheses

The secondary review of later prehistoric demography has focused largely upon individual site populations, and where inferable, population levels of regional or inter-regional polities. This derivative data base may reflect modal, dia-chronic variation in population densities in both the Hercynian and Pannonian zones (cf. Figs. 4-13, 99, 105-107, 110, 129 and 145). Such secondary data will then be compared to a suite of primary pollen sites (see esp. back jacket and Figs. 50-51, 58 and 63) in order to gauge population and cultivation levels through time in both bio-geographic zones, although the Pannonian pollen data base is bolstered by the well-dated, secondary lacustrine sequence at Mistřín in South Moravia (Fig 20). An in-phase alignment of high cultivation with high population (density) reconstructions will allow for the negation of the general Behaviouralist hypothesis, while alignment of maxima in the cultivation-population parameters with climatic maxima will conversely affirm the Climatic hypothesis. Thus a real culture-nature dynamic is inferable after the later prehistoric settlement cycle.

Once later prehistoric cultivation levels are compared to base-line Early Medieval pollen spectra (which may be taken to represent the condition of absolute land circumscription), an assessment of relative land circumscription in later prehistory is made. An appraisal then of the non-importance of the land-circumscription factor in relation to regional polity formation will allow for a negation of the Carneiro hypothesis regarding the (absolute) extension of the principle of competetive exclusion (vis à vis land shortage) to the emergence of complex human society.

Relative vs. absolute competetive exclusion in later prehistoric Central Europe

Regardless of complexity, consideration of the relative rather than absolute application of the principle of competetive exclusion in human societies can be made in the case of the Hallstatt D Vekerzug Horizon (ca. 600 cal. BC). Observations of an environmental pulse of sub-xeric climate in Hallstatt D (1-2) are made in Chapter 4, which are corroborated by pollen spectra from Vojkovice and Pohořelice (reviewed in Chapter 7). In tandem, these geo-botanical data indicate that moisture-stress on the Hungarian Plain might have promoted a Vekerzug pastoralist incursion into better watered pastures on the western margins of Pannonia and into Moravia.

In this relative context, competetive exclusion is employed as a concept which weighs the relative demographic-societal costs of remaining in an environment of reduced environmental K capacity against potential demographic costs of inter-group or inter-polity warfare. In trying to employ the Lotka-Volterra matrix in a case scenario, problems of detail arise in the derivation of Lotka's co-efficient of competetive exclusion, which in this context must reflect the martial advantage of one group *vs.* another due to differences in in military technology or the defensive value of fortifications. Still more problematic is the limited population biological concept of exclusion adopted by Carneiro, which treats organisms as individuals which exclude other organisms as a function of gross population levels, while in human situations, populations of individuals seem to be integrated into groups prior to the emergence of true social complexity. Thus in human situations, competetive exclusion may be a partial function of group integration rather than an explanation of further elaboration of that same group integration function.

Context of raiding and warfare or direct competition

Returning to the cultural and demographic context of direct competition, the expression of competetive exclusionary behaviour (a.k.a. raiding and warfare) will be compared to the coincidence of inferred systems of socio-political integration at variant population levels. Care is taken to make distinctions between different levels of raiding or warfare and its motive content. Interestingly, early raiding and warfare appears to be motivated by ideology with a focus on social status or enigmatic cult rather than identifiable material factors such as land and raw resources (cf. Figs. 100 and 111). Later warfare furthermore reflects an orientation of conflict away from intra-cultural local groups, as such warfare becomes more limited to definable cultural boundaries (see Fig. 131 and pertinent discussions in Chapters 11 and 12).

Of the exclusionary significance of systems of socio-political integration towards enhancing group success, linkage between warfare and the formation of regional polities is suspected. Such integration is limited by absolute population levels, as well as warfare itself, which in its more intensive modes serves to limit population both directly and indirectly. Indirect limits imposed on population include the redirection of labour away from subsistence ends and a promotion of less-effective land-use with the development of defensive settlement postures.

Archaeological culture and adaptation

Patterns of culture-historical data are considered finally in an adaptive light, as it is suggested that the restraint on variety imposed by cultural norms may promote or denude human adaptation of populations participating in such cultures. Under stable conditions, cultural constraint on variety enhances conformity of the culture-participant with the environment with which a culture enjoys an stable equilibrium state. With environmental change, a constraint-imposed lag in cultural adaptive adjustment may reduce such conformity, producing mal-adaptation in non-adjusted populations. In extreme situations such as the case of the Norse settlement of Greenland, failure to adjust the cultural-adaptive pattern in the wake of the Little Ice Age minimum leads to complete cultural extinction. In later prehistoric Central Europe, more subtle cultural ecological patterns are observed in two material cultural hypotheses which explain cultural diffusion and variegation as modulated by agro-climate and population.

This treatment of material culture respects culturally imposed adaptive limits. Ecologic dynamics considered in this work are the environmental correlates of directional cultural diffusion (Hypothesis A: somatic adaptive limits) and the spatial scope of information flow through populations (Hypothesis B: kin network limits), as both (A and B) are modulated by factors of (1) population density and (2) socio-political systems which channel population interaction and information flow. These culture history patterns may be modulated also by changes of adaptive focus away from subsistence and towards warfare between larger (linear?) tribes.

Levels of agricultural intensity at Vranský potok

Although pollen analysis has been intentionally employed towards archaeological lines of enquiry, unintentional if significant pollen methodological inferences have been drawn during the course of this work. In this concluding chapter, a focus will be made upon defining levels of agricultural intensity after data from the primary site of Vranský potok.

Once differential pollen recruitment effects are eliminated, relative degrees of cultivation intensity in alluvial sediments may be defined by Levels 1-5 (below) in order of decreasing intensity (note that primary cultivation indicators include all cereals [*Cerealia*, *Triticum*, *Hordeum* and *Secale cerealia*], flax, hemp and hops):

1. Very intensive cultivation

   A. Primary cultivation>8% (rational), syn-anthropic flora annual dominant (rational)

   B. Hydrology high (alluvial sub-competence obscures some pollen indicators of this), N.A.P.<5% (consistent)

2. Intensive cultivation

   A. Primary cultivation>2% (semi-rational), syn-anthropic flora annual prominent (rational)

   B. Hydrology high, N.A.P.<10% (less-consistent)

3. Extensive cultivation

   A. Primary cultivation 1-2% (semi-rational), syn-anthropic flora perennial dominant with annuals (rational)

   B. Hydrology high, N.A.P. 10-30% (lower range more common)

4. Cyclical cultivation

   A. Primary cultivation 0-2%, syn-anthropic flora perennial dominant with sporadic annuals

   B. Hydrology variable, N.A.P. 15-40% (generally variable)

5. Recessionary phase (a.k.a. woodland regeneration phase)

   A. Primary cultivation<1%, syn-anthropic pollen perennial dominant (sporadic)

   B. Hydrology low, N.A.P. 20-50% (higher than prior phase)

A tendency for A.P. values to fall quickly from Levels 5-4, and then cluster within the 10-15% A.L.P. range in Levels 4-2, with only incremental decreases there-after with increasing cultivation intensity (to Level 1) suggests that the mathematical relationship between actual levels of aforestation and A.P. percentages is logo-rhythmic rather than linear. This logo-rhythmic pollen percentage to land-use relationship might follow from the fact that N.A.P. representation increases not only with deforestation, but also with increased erosion and flood-loam deposition (soils containing syn-anthropic taxa) ensuing from this same deforestation.

Prehistoric land-use patterns exhibited at Vranský potok after Medieval base-lines

At Vranský potok, a complete clearance of primary agricultural land with short (2-3 year) fallows corresponds to the very intensive intensive agricultural regimes of the Early Slavonic to High Medieval period. On this comparative basis, it might be retroactively projected that the intensity of land-use at Vranský potok varies at lower ranges during pre- and proto-history.

Periods of higher agricultural impact are reflected in secondary cultivation indicators at the following levels with hypothetical fallows after relative weed composition (inclusive of "out-fields") indicated. The methodology employed to calculate fallows depends on the proportion of annual vs. perennial weeds after the methods of K.-E. Behre, in which only with very intensive agriculture will annuals out-number perennials, while under extensive cultivation, only a minor admixture of annuals might be encountered.[1] Dating of the so-called pre-Bronze Age to earlier Bronze Age periods are considered as provisional. Associations of archaeologic periods with palynological zonal ranges rather than specific zones are made in recognition of this limitation:

Table 14.1. Later prehistoric and proto-historic agricultural maxima at Vranský potok

Time period	*arboreal pollen (A.L.P.)*	*arable fallows (including out-fields)*
1. Pre-Bronze Age? (Zones 1-2?)	ca. 10-15%	5-10 years
2. Earlier Bronze Age? (Zones 3-4?)	ca. 10-15%	5-10 years
3. Early Knovíz Urnfield (Zone 5)	ca. 10-15%	5+ years
4. Late Hallstatt (Zone 11)	ca. 10-15%	5+ years (with minor winter cultivation)
5. Early Roman (Zone 16)	ca. 10-15%	3-5 years (with minor winter cultivation)
6. Early Slavonic (Zones 18-20)	ca. 2-3%	2-3 years (with major winter cultivation)

Periods of high human impact on flora thus synchronise with high-impact phases (I-III) of the secondary geo-botanical data base (cf. Chapter 5 and Figs. 14-15). An inferred pre-Bronze Age cultivation phase (Period 1) is acute. Hypothetically, the agrarian intensity of this first pulse is sufficient to initiate alluvial accumulation, albeit at slow rates. A further threshold of human impact is crossed then in the earlier Bronze Age (? Period 2), with the deposition of silty "flood-loams". These erosional sediments are comprised principally of reduced silts, with smaller proportions of clay, suggestive of higher energy depositional environments relative to the lower zone clays. An emphatic pulse of agrarian settlement is noted during the Early Knovíz period (Period 3). Denuded woodlands, high cultivation and high water tables are achieved within a century, reflecting a rate of forest clearance in the order of (ca.) 1 km^2/generation by a farming population in the lower hundreds, within a (ca.) 15 km^2 catchment of the second order reaches.

1 Behre 1981

Between dual Urnfield extensive cultivation phases, a pronounced woodland regeneration then transpires (ca.) 1100 cal. BC (Zone 7), around Hallstatt B1-2. This recession (cf. [tephra] dates for Hekla III of 1087-06 cal. BC) endures for a period of 50 to 100 years between the Knovíz and Štítary phases. Conversely, the Hallstatt C Iron Age provides ambiguous evidence for an agricultural decline despite a widespread devolution of settlement in the post-Urnfield period. An agriculture expansion then proceeds slowly during the following Hallstatt D period.

In accord with settlement data patterns is a phase of relaxed anthropogenic impact expressed in the Middle La Tène, coeval with a phase of unfavourable (Sub-Atlantic) agro-climatic conditions (ca.) 400 (cal.) BC. Woodland regeneration entails a local lowering of the water table in spite of cool-wet Sub-Atlantic conditions, although the *Typha* rise vis à vis *Cyperaceae* indicates that relative fluctuations in the water table were none-the-less reduced in this wet climatic period.

A major interruption of agriculture in tandem with an inferred drop in water tables occurs at the transition to the Early Roman period. This interface is concurrent with a transformation of settlement structure in Central Bohemia, affirming the disjunctive significance of this structural change. This agrarian recessionary phase is followed by the first truly intensive (Early Roman) period (5) of agriculture at Vranský potok. Still more intensive is the agriculture of the Early Slavonic period (6), with the introduction of the mould board plough and winter rye cultivation.

Between cultivation phases, the geo-botanical site of Vranský potok also expresses an enduring tendency for woodland regeneration in the absence of proximate human impact. After intensive cultivation, a sub-climax equilibrium of mixed-oak woodland communities may be achieved within the order of one to two centuries. This is expressed by the rapid regeneration of primary woodland during the Tumulus (Zone 4), Knovíz-Štítary (Zone 7) and Middle La Tène (Zone 13) recessions of agriculture. Some woodland recovery also occurs (after radio-metrically-established sedimentation rates) around AD 900, concurrent with the historic period of pastoral nomadic Magyar incursions from Pannonia into Central Europe.

Steppe development in Pannonia

The Pannonian bio-geographic zone, in contrast to Hercynia, exhibits a cumulative progression of deforestation and steppe development (see Fig. 55). Relaxation of agricultural settlement intensity does not lead to woodland regeneration. From this, it may be inferred that the mixed-oak woodland in Late Holocene Pannonia represents a biome at meta-stable equilibrium, maintained by the sustenance of a favourable soil micro-climate under the forest canopy. Once this canopy is removed, preconditions for forest growth are also removed. This meta-stable equilibrium hypothesis finds support in the association between certain pedogenic processes and prehistoric features or pottery. Initially during the Early Bronze Age, brown forest soils are transformed into czernozems in the locus of the Jelšovce cemetery in the Middle Nitra Valley (Fig. 105). More emphatic is an Urnfield horizon of rendzina formation in Central Europe, with the precipitation of calcium carbonate indicative of sub-xeric soil micro-climates associated with Urnfield settlement. *Circa* 1000 uncal. BC however, COHMAP's reconstructed rates of actual to potential evapo-transpiration vary from -0.1 to +0.1 in Temperate Europe, and from +0.0 to +0.2 on the Hungarian Plain, indicative of marginally higher precipitation. These alternate data, which factor out human impact, underline the importance of the human impact factor in dry steppe formation, as most other proxy sources for dry climate are linked to settlement loci.

After Včelínce, a well-developed steppe might be reconstructed for the Eastern Carpathian Basin in the Early Bronze Age (Fig. 56). Effective precipitation rates are estimated to be (ca.) 700 mm *per annum* during the Hatvan period here. With the Classical Early Bronze Age Hatvan-Otomani period (coeval with the Věteřov-Mad'arovce "mini-optimum"), rates as low as 600 mm *per annum* are projected. During the Urnfield (Kyjatice Culture) period, high temperature stress or human impact might also account for a poor *Pinus* response at Včelínce.

More mesic conditions are reconstructed from the Early Bronze Age Nitra Culture grave sample at Mýtna Nová Ves in the West Carpathian Basin, with precipitation reconstructed at 7-800 mm *per annum* (Fig. 58). This range falls to 6-700 mm after alluvial pollen spectra (tenuously) correlated with the earlier Bronze Age period. Notably, these and subsequent alluvial spectra register a progressive clearance of mixed-oak and alluvial woodland without a significant forest regeneration phase intervening, even where primary cultivation indicators are lacking. The Nitra valley landscape is not largely "steppic" until the final alluvial spectrum.

Sites of the Early Iron Age Horákov Culture (Figs. 59-63) attest to the first emergence of fully steppic floral communities at the northwestern periphery of the Carpathian Basin, when effective precipitation rates of only 450 mm *per annum* are reconstructed during Hallstatt D1-2.

Localised pollen spectra at four Roman camps of the Marcomannic Wars are further affirmative of the prevalence of a Pannonian steppe by AD 166-80 (cf. Figs. 65-75). An exaggerated response by *Compositae lig.* type pollen is suggestive of the promotion of a halophytic flora through soil exposure or woodland denudation which reduces moisture penetration or raises to floodplain water table to the rhizosphere. Because these camps house whole cohorts and occur in regional clusters, a high degree of anthropogenic impact is not inconsistent with the pollen evidence.

Test of the behaviouralist hypothesis after primary and secondary pollen data

Maximum archaeological site populations in Hercynia and Pannonia as reconstructed in Chapters 9-12 are now compared to aggregate primary cultivation pollen indicators from a composite of sites. It is assumed that the site population levels reflect local population densities rather than regional levels. Pollen sites and dating methods employed as an independent test of the Behaviouralist hypothesis are keyed-in below. These same geo-botanical sites will also be used towards a test of the Climatic hypothesis in Central Europe.

Table 14.2. Pollen sites used to test Behaviouralist and Climatic hypotheses in Central Europe.

Time period	*Hercynia* *site (dating method)*	*Pannonia* *site (dating method)*
Middle Eneolithic	(nrd)	M (R)
Late Eneolithic	(nrd)	M (R)
Early Bronze Age (Early)	VP (eR?)	M (R), MNV (A)
Early Bronze Age (Classical)	VP (eR?)	M (R)
Middle Bronze Age	VP (R)	M (R)
Late Bronze Age	VP (R)	M (R)
Hallstatt C	VP (R)/Vi (A)	Vo (A)
Hallstatt D1-2 (Vekerzug Horizon)	n/a	Po (A)
Hallstatt D/La Tène A	VP (R)/Vi (A)	
Middle La Tène	VP (R)	
Late La Tène	VP (R)	
Early Roman	VP (R)	
Late Roman	VP (R)	

Key to Table 14.2. Sites: VP = Vranský potok, Vi = Vinoř, M = Mistřín (secondary site), MNV = Mýtna Nová Ves, Vo = Vojkovice, Po = Pohořelice. Dating: (R) = radio-carbon, (eR?) = extrapolated (relative) radio-carbon within dated main sedimentary zone, (A) = archaeological, (nrd) = no reliably dated pollen data, n/a = not applicable

Maximum site populations through time are now compared below to primary agricultural indicators (maximum for period). Hill-fort, Oppidum and Lovosice macro-type sites are designated (m) separately from mean hamlet-village populations (v), as are population estimates of cemeteries (c). Modal population of Hallstatt C settlements in Hercynia is assessed as density per hectare. In Early Iron Age Pannonia, Danubian modal populations are maintained into Hallstatt D1, although a retreat into small hill-forts by Late Lusatian Culture communities during the "Vekerzug Horizon" should be noted. Multiple cultivation values (%) follow the respective order of pollen sites listed in the above table (14.2) in the following tables (14.3-5).

Table 14.3. Maximum primary cultivation and maximum site population in Central Europe.

Time period	*Hercynia*		*Pannonia*	
	cultivation (%)	*site population*	*cultivation (%)*	*site population*
Middle Eneolithic	nrd	n/a	0.8	175 (m)
Late Eneolithic	nrd	n/a	0.0-0.2	30 (v)
Early Bronze Age (Early)	0.0?	20-25 (v)	0.5-1.1/2.3	5-10 (v), 70 (c)
Early Bronze Age (Classical)	1.1?	65 (v), 60-70 (c)	2.5	100 (v), 215 (m)
Middle Bronze Age	0.0	5-20 (v), 25 (c)	0.0	20 (v)
Late Bronze Age	2.3	120 (v), 250 (m)	1.6	120 (v), 250 (m)
Hallstatt C/D1	1.6/0.7	5/hectare (v)	6.2	140-175 (v, Danubian)
Hallstatt D1-2 (Vekerzug Horizon)	n/a	n/a	1.5	destruction horizon
Hallstatt D2-3/La Tène A	1.4/4.6	130 (v), 250 (m)		
Middle La Tène	0.0	20 (v)		
Late La Tène	2.1	20-40 (v), 2-4,000 (m)		
Early Roman	6.5	55-135 (v)		
Late Roman	1.1	15 (v)		

Key to Table 14.3. n/a = not applicable, nrd = no reliably dated pollen site

Although only a limited comparative range is available in Pannonia (no. modal, discrete pollen periods=8), a 100% positive co-variation between maximum cultivation and site population indicates that actual periodic cultivation levels and perceived concentrations of settlement remains are positively linked. In the Hercynian sequence (no. of analytic periods=12), the rate of positive co-variation between cultivation and settlement concentration is 92%. Excluding periods of lower chronological definition as indicated by query, the co-variation is still maintained at a satisfactory 80% level of covariation.

Although individual base-line cultivation percentages are too low for 95% confidence, a negation of a general Behaviouralist hypothesis is affirmed in the aggregate of inter-zonal evidence. Notably, the singular negative co-variation episode (of Hallstatt C date) at Vranský potok might reflect problematical statistical confidence limits for individual events, or else that the local settlement tendency is not regionally typical (the 15-30-50 km^2 hypothesis). Conversely, the Vinoř data display positive co-variation between Hallstatt C and D. An empirical ambiguity of the Hallstatt C period is thus revisited in local *vs.* micro-regional pollen responses.

In spite of a negation of the general Behaviouralist hypothesis, it should be observed that in quantitative terms, the amplitude of syn-anthropic pollen oscillation is less than concurrent proportional changes in maximum settlement population. Generally speaking, an increase of (ca.) 50% in primary cultivation levels is accompanied by a (ca.) 1-200% increase in (maximum) reconstructed site populations. Thus, although settlement data reflect the general trajectory of human land-use, the amplitude of population change is exaggerated. Emphatically low registration of settlement features of low population concentration periods may then be attributable to population dispersion in periods of demographic decline. A methodological inference then is that Corded Ware, Bell Beaker, Tumulus Culture, Hallstatt C, Late Roman and Migration period settlements will be difficult to detect when these occur as isolated components.

The Climatic hypothesis in the Hercynian context

With the negation of the (general) Behaviouralist hypothesis (although the notional importance of settlement dispersion is not fully explored), affirmation or negation of the Climatic hypothesis is now deduced on the basis of primary pollen data from Vranský potok and Vinoř, together with the palaeo-climate data base of Central Europe. Notably, certain phases are (climatically) recognised in this comparison which are not recognised as culturally significant. These "cultural interface" periods include an Early Hallstatt B Knovíz-Štítary transitional phase, and a Late La Tène-Early Roman cultural interface (at Vranský potok, Zones 7 and 15). Pollen sites are used and abbreviated as above (cf. Table 14.3). Palaeo-climate is designated as "Max. I" (modal maximum, 1-2 degrees C above present summer temperatures), "Max. II" (emphatic maximum, 2-4 degrees C above present summer temperatures), "Min. I" (modal minimum, near or just below present day summer temperatures), "Min II" (emphatic minimum, 1-2 degrees C below present summer temperatures) and "Trans." ("transitional", summer temperatures variable, but usually just above present day conditions). Due to problems of imprecise dating, the potentially Eneolithic aspects of the Vranský potok sequence are omitted from consideration at present, while Early Bronze Age dating is considered to be provisional.

Table 14.4. Syn-anthropic geo-botanical indicators compared with secular climate (Hercynia).

Time period	*cultivation (max.%)*	*primary woodland (%)*	*relative hydrology*	*agro-climate*
Early Bronze Age (Classical)	1.1 (dating?)	9.4 (min.)	high	Max. I
Middle Bronze Age	0.0	39.0 (max.)	low	Min. II
Early Urnfield	2.0	7.9 (min.)	very high	Max. II
Knovíz-Štítary (transition)	0.0	31.0 (max.)	low	Trans.
Late Urnfield	2.3	11.6 (min.)	high	Max. I
Hallstatt C/D1 (VP/Vi)	1.6/0.7	21.4/2.0	high	Min. I-Trans.
Hallstatt D2-3/La Tène A (VP/Vi)	1.4/4.6	10.9 (min.)/0.0	high	Max. I
Middle La Tène	0.0	25.6	very low	Min. II
Late La Tène	2.1	9.6 (min.)	variable	Min. I-Trans.
La Tène-Roman (interface)	0.0	28.6	low	Trans.
Early Roman	6.5	7.8 (min.)	high	Max. I
Late Roman	1.1	6.6-10.1 (range)	low	Min. I

Note then that Vinoř (Vi) reflects the proximate syn-anthropic flora of Hallstatt C to D date, while Vranský potok (VP) reflects micro-regional conditions. Respecting also the above sub-Behaviouralist hypothesis that settlement dispersion might account for "low population" phase phenomena, the higher relative cultivation values of Hallstatt C date at Vranský potok *vs.* Vinoř might be cited as support of this. In short, local cultivation intensity may be dramatically reduced by settlement dispersal, although these effects will become muted as the pollen catchment takes-up a larger land-use area of recruitment. Significantly, Kuna has also noted a uniquely high rate of incidence of Hallstatt C Bylany Culture sherds outside primary agrarian settlement cells in the Archaeological Institute's "North Bohemian Landscape Reconstruction Project".[2] This period then might be one of particularly dispersed settlement which under-rates absolute population levels. The co-existence of tiny hamlets and chiefly chamber burials of the Bylany and Early Horákov cultures reinforces this view, as it seems intrinsically unlikely that the slight populations directly perceived after settlement archaeology could harness the requisite material resources necessary towards the furnishment of the latter mortuary complex.

Thus in Hercynia, a general (ca.) 87% positive co-variation rate between three (internally co-variant) syn-anthropic vectors and Central European agro-climatic parameters is registered. Excluding the queried (provisionally dated) Early Bronze Age period, a general (ca.) 84% positive co-variation rate between three (internally co-variant) syn-anthropic vectors and Central European agro-climatic parameters is still registered.

Together with relative agro-climatic maximisation, these vectors are defined as a positive pollen response of primary cultivation taxa, a negative pollen response of primary woodland taxa and a positive response of hydrology (inferred on the basis of both sedimentology and palynology). Together with relative climatic agro-climatic minimisation, these vectors are defined as negative pollen response of primary cultivation taxa, positive pollen response of primary woodland taxa and negative response of hydrology. The Hallstatt C period presents empirical ambiguity for an agricultural recession, while the agricultural disjunction of La Tène-Roman interface conversely occurs in the absence of a minimising agro-climatic stimulus. As was discussed in Chapter 2, this latter period is one of most-significant disjunction of the structure of the settlement landscape in Central Bohemia (cf. Figs. 9-10). Micro-regionally then, the occurrence of a recession in agricultural is suggestive of an acute disruption of the settlement regime.

Generally, these data are strongly affirmative of the Climatic hypothesis with periodic reservations after the Late Bronze Age, even in view of the problematic dating of earlier periods

2 M. Kuna pers. comm., 1994

whose potential associations may ultimately give additional support to the affirmative test of this hypothesis. Cultivation intensity increases with increased growing season length assessed in terms of degree days over 10 degrees C. Further comparative data from more drought-prone Pannonia are thus of interest towards an inter-zonal test of the Climatic hypothesis.

The Climatic hypothesis in the (comparative) Pannonian context

Affirmation or negation of the Climatic hypothesis in the Pannonian bio-geographic zone is limited by virtue of the restricted primary pollen data base. In view of this fact, secondary palynological data from the South Moravian lake site of Mistřín will serve to provide comparative pollen spectra for the Eneolithic and Bronze Age periods, where radio-metric controls are superior (no. of later Holocene assays = 4). Because woodland clearance is perceived to be largely cumulative rather than cyclical, A.P. response is not considered as a parameter in the Northwest Carpathian Basin, although localised effective precipitation (L.E.P.) is considered as a significant and possibly anthropogenic vector in steppe formation. Notably, arable agriculture appears to thrive in the 6-700 mm L.E.P. range within Pannonia. Note that the alluvial aspect of Mýtna Nová Ves is queried ("?") in the second L.E.P. entry of this table, although it should be noted that a multiplicity of sequential spectra of potential Early Bronze Age date are used.

Table 14.5. Primary cultivation and L.E.P. compared with secular climate (Pannonia).

Time period	*cultivation (max.% [site])*	*climate (localised effective precipitation)*
Middle Eneolithic	0.8 (M)	Max. I
Late Eneolithic	0.2 (M)	Min. I
Early Bronze Age (Early)	1.1/2.3 (M/MNV)	Trans. (7-800 mm per annum, MNV)
Early Bronze Age (Classical)	2.5/3.0 (M)	Max. I (6-700 mm per annum, MNV)
Middle Bronze Age	0.0 (M)	Min. II
Late Bronze Age	2.0 (M)	Max. I-II
Hallstatt C/D1	6.2 (Vo)	Min. I-Trans.
Hallstatt D 1-2	1.5 (Po)	Max. 1 (450 mm per annum, Po)

Significantly, higher cultivation levels are attributed to periods of "modal" (Max. I) rather than "emphatic" (Max. II) climatic maxima within Pannonia. Also vis à vis Hercynia, moderate agro-climates associated with "transitional" (Trans.) phases are more closely associated with higher primary cultivation values within the Pannonian zone. This data pattern indicates that different limiting factors on agriculture as imposed by bio-geography evoke different responses in Pannonia compared to Hercynia. Specifically, sensitivity to moisture deficits of dry agriculture in Pannonia is suggested. Syncopated patterns of cultivation development in the two bio-geographic regions thus appear during the Bronze and Early Iron Ages, reflective of differences in the climatic limits on agricultural potential. Thus dia-chronically, moderately warmer climates of the Classical Early Bronze Age produce higher cultivation values vis à vis the Late Bronze Age maximum in Pannonia. The reverse is the case in Hercynia (although both zones register an agrarian decline in the Middle Bronze Age). In support of the pollen data, Havlíček's Morava River flood-loam radio-carbon dates cluster in the Classical Early Bronze Age period, signifying increased soil erosion in Pannonia, while the Bohemian sites of this work, as well as alluvial sites of Kuna, Butler and Beneš in North Bohemia register a Late Bronze Age cluster of chronometric indicators in basin flood-loams of the Vltava, Elbe and Ohře.[3]

In inter-zonal terms, Early Iron Age cultivation values are also higher at the earlier Horákov (Hallstatt C/D1) site of Vojkovice relative to the later (Hallstatt D1-2) site of Pohořelice, where effective precipitation in South Moravia is limited to near a crucial biologic productivity threshold of 450 mm *per annum*. In contrast, the primary Bohemian pollen sites register an increase in cultivation during the sub-xeric secular oscillation of Hallstatt D. Bohemian agriculture thus responds more favourably than that of Pannonia to sub-xeric climate phases.

Generally, the comparative Hercynian-Pannonian geo-botanical data base indicates that prehistoric agriculture is periodically limited by climatic forcing. These minima reduce the growing season and denude arable agricultural productivity. Adaptive adjustments to such natural limits might include the adoption of widely edaphic (often less productive) crops or shifts in the balance of arable *vs.* pastoral agriculture (favouring the less productive pastoral aspect), shifts which also systemically effect settlement structure, producing population decline and inducing relative population dispersion. Although lower rates of (Kcal.) production would entail lower general population levels, systemic transforms of the settlement structure might exaggerate this "depopulation" effect in the discerned archaeological record, as more (micro-) mobile and

3 Butler n.d., Beneš n.d., cf. Willis et al. 1998

dispersed populations may produce less substantial settlement remains.

The materialist test of the political extension of the competetive exclusionary principle

After geo-botany, agricultural intensity in later prehistoric Central Europe is cyclical, with maximal syn-anthropic pollen response characterising certain periods associated with favourable agro-climates. The general pattern of agrarian settlement is not one of incremental increase in agricultural intensity following E. Boserup (although base agricultural productivity has certainly increased by the Early Middle Ages compared to prehistoric times). In comparison with base-line Medieval pollen spectra (with primary cultivation pollen responses in the order of 8-15%), pre-Roman extensive cultivation phases at Vranský potok register values in the order of 2-3% (and locally, 3.6% from the Knovíz occupation at Konobrže and 4.6% at Late Hallstatt Vinoř). Pannonian Bronze Age sites also register no primary cultivation values above 3-4%, while an acute high (6.2%) at the Early Iron Age site of Vojkovice is exceptional in this respect (note the situation of the Horákov grave, flanked by dual settlement sites above the Svratka River). High (rational) cultivation values (up to 6.5%) of Early Roman date at Vranský potok might be more significant of micro-regional "moderate agricultural land shortage" in proto-history.

Agricultural land-shortage in the absolute sense ("Level 1" or "very intensive cultivation") is not expressed by prehistoric primary cultivation values, which are indicative of more extensive regimes where an absolute shortage of prime arable land would appear to be an operative factor of political-economic relations between local groups and regional polities. A negation of the Carneiro hypothesis can then be affirmed, in that the dual settlement (after palaeo-demography) and mortuary evidence is indicative after of a restrictive emergence of regional polities first in the Early Bronze Age of Pannonia, and then a more general development of such in the Late Bronze Age of Pannonia and Hercynia in the absence of necessary competition over prime arable land.

The notion that the development of regional or inter-regional polities is necessarily enabled by simple act of conquest is also negated by Iron Age data patterns. For example, the juxtaposition of social evolutionary "state change" and evidence for warfare is not constant. No evidence for "internalised warfare" accompanies the foundation of the Late La Tène Oppidum and Lovosice-site system, nor does the abandonment of Oppida occur within the context of regional inter-tribal warfare. Conversely, limited evidence for "raiding or warfare" does occur under higher population densities among local groups during the Middle Eneolithic of Bohemia and Moravia.

Distinct from inter-agrarian-conflict, pastoralist-agrarian inter-action is governed by significant martial-technological differences between such groups which will be treated in a case scenario after primary and secondary data of the Early Iron Age. In this context, the pastorally-oriented Vekerzug Culture of the Hungarian Plain may be defined as significantly integrated in its regional population after the scale of the mound construction at Včelínce. This and other mounds in the East Carpathian Basin are also built during a period of material cultural exchange with the Danubian Hallstatt cultures, probably part of an inter-regional elite-interaction sphere. Only later (Hallstatt D1-2) does evidence for a series of Vekerzug incursions into the Northwest Carpathian Basin or the Lusatian cultural zone occur in a milieu of ecological stress.

The Vekerzug case and the hypothesis of relative competetive exclusion

That the competetive exclusionary principal is <u>necessarily</u> extended to political coalescence in tandem with the nodal importance of absolute land shortage is negated above. However, subsistence concerns might still be invoked in the promotion of competetive exclusionary behaviour, although should one employ Lotka-Volterra in its entirety (<u>unlike</u> Carneiro), this behaviour need not result in a single "victor", for dynamic equilibrium (no "victor") conditions are also modeled, depending on the modulating factors of the co-efficient of competetive exclusion and effective scales of population integration towards martial ends. The (significantly) pastoralist Vekerzug (Hallstatt D1-2) Horizon is now considered, modifying Lotka-Volterra to account for the formation of larger socio-political units.

With the emergence of the Vekerzug Culture in West Slovakia, an initial period of co-operative interactions can be envisioned in the exchange of fine iron weapons and equestrian regalia into Moravia and Bohemia. The rise of a pastoralist culture-cum-techno-complex reflects an ecologic adaptation to the deforestation and steppification of the Carpathian Basin in the Bronze Age, Evidence for incursions into temperate Europe dating to Hallstatt D1-2 are then coeval with a reconstructed sub-xeric secular oscillation, when effective precipitation as low as 450 mm *per annum* is reconstructed in South Moravia. It might also be noted that the coeval Bronze Age VI period in West Poland produces considerable lake-level evidence for dry conditions at Lusatian lake-forts.

In this vein, it is important to note that the live above-ground bio-mass of pasture declines in a <u>linear relationship</u> with precipitation below a 450 mm threshold. Because effective precipitation will be necessarily less in the interior Carpathian basin (with a negative differential of ca. 100 mm), the *K* capacity of the interior steppe will decrease by (ca.) 20% during the Hallstatt D1-2 oscillation. Because pastoralists depend on grassland bio-mass for subsistence, environmental perturbations reducing the *K* capacity of steppe may lead to any number of adaptive adjustments, including direct competition for agricultural land, and particularly that of well watered pastures.

The co-efficient of competetive exclusion vis à vis later prehistoric pastoralists and farmers

In the general case of pastoralist societies, an intrinsic combative advantage can be expected vis à vis an unmounted foe. Respecting the Vekerzug Culture specifically, a ranked society with a martial ethos is also indicated after the scale of mound construction at Včelínce (equal to up to 12,400 man-days of labour) in East Slovakia and the relative contents of graves at Chotín in West Slovakia. On the basis of very extensive funerary finds from Chotín and the scale of the Včelínce mound, the mean regional polity size of the rider folk is likely to have exceeded 1000 (Figs. 107, 123-124).

The possibility that the more-continental areas of the Carpathian Basin are partially evacuated by Vekerzug pastoralists for already occupied more-temperate grasslands may then be plausibly entertained as will be explained, an adaptive choice which weighs the potential demographic costs of direct inter-group competition (raiding-warfare) against the same costs of remaining in an environment of reduced *K* capacity. Respecting apparent agrarian "targets" as discerned after archaeological evidence, "modal" Platěnice Phase settlements would probably contain 50 to 100 inhabitants, with local groups only weakly integrated with each other. Significantly, hill-fort distributions in the Platěnice settlement zone of Middle Moravia are not suggestive of quasi-central place functions; rather, these lie at the perimeter of this Morava basin zone (Fig. 113).

Having proximately capped Lotka's population factor to accommodate the sizes of local Platěnice *vs.* integrated Vekerzug communities, a co-efficient of competitive exclusion (reflecting the rider's martial advantage) must still be derived. In seeking an accurately-described ancient battle between foot and horse to reconstruct this co-efficient, the encounter of Marcus Licinius Crassus with Parthian horsemen at Carrhae (53 BC) serves as a derivative account.

Plutarch's account of Crassus in his Parallel Lives is meant as a moral example of how a Roman commander should not behave in the face of adverse circumstances, thus glorified accounts of the number of Parthian foes need not be expected in the account of the battle. In short, Plutarch's story goes that in straying from areas giving intrinsic advantage to his footmen, Crassus' army of 28,000 (mixed) infantry and 4,000 (mixed) cavalry is readily defeated by a purely mounted force of 1,000 cataphracts (armoured horse) and 10,000 horse-archers in open ground. Assuming that minimally, we must assume tactical parity to allow for a Parthian victory, the most optimistic co-efficient of foot-to-horse military effectiveness to be derived (algebraically) from the footman's point-of-view might not be more than 1:4 (outside of prepared positions). Thus the competitive exclusionary costs per 1000 members of a Vekerzug "polity" might be less than 25% of the Platěnice combatants, or a maximum cost of two to five Vekerzug individuals per 1000 members in conflict with any given Platěnice local group. This assumes that the adult male aspect (ca. 20%) of each population engages as active combatants.

Given then the contemporary linear decline in areal *K* capacity of the steppe with summer-time precipitation losses below 450 mm *per annum*, it can be expected that (ca.) 20% of live above-ground bio-mass is lost in the interior steppe during the Late Hallstatt period. Also given Vekerzug polities of (ca.) 1000 individuals, the total demographic costs of not migrating into better-watered, settled agricultural territory is (ca.) 200 individuals per Vekerzug polity. This "remain in-situ" option would approximate the demographic cost of direct competition with 40 to 100 local Platěnice groups occupying 400 to 1000 km^2 of prime pasturage (inclusive of inter-fluves) on the northwestern margins of the Carpathian Basin. That direct competition might have been induced by somatic adaptational concerns must remain conjectural; however, that the Vekerzug population actually acted under duress is suggested by their (successful) attempts to take heights like Zelená Hora and other refugia in Middle Moravia (cf. Fig. 113).

These Platěnice "refugium" hill-forts in the Drahanské Vrchovina reflect an effort to reduce the intrinsic pastoralist combative advantage of the inter-lopers, perhaps the first of a long series of pastoralist incursions into Central Europe until the Middle Ages by nomads with a martial advantage. Significantly, that cultural exchange with the Vekerzug is continued by the Late Hallstatt-Horákov populations of Bohemia and Moravia up to the "incursion horizon" is indicated by finds of weaponry and horse gear, as well as formal "influences" in the mortuary cult burial orientation and ceramic typological forms (e.g. at Poláky).

That Danubian cultural populations were more strongly integrated into regional polities also suggests that there is an effective "cultural selection" of Vekerzug "targets" towards smaller political entities of the Lusatian cultural zone. The "competitive exclusionary principle", instead of explaining the rise of larger political units, is then in fact itself modulated by larger political formations, which effectively replace gross population levels in the matrical equation of Lotka-Volterra. In essence, natural parameters of direct competition or warfare are preempted by cultural factors in societies possessing even a degree of wider integration, but such culturally modulated warfare (-raiding) can still be modeled after basic population biological constructs.

In this light, direct competition or warfare between agrarian groups and its long-term effects on the scale of agrarian population integration is now reviewed in the Central European context.

Socio-political adaptations to warfare of later prehistoric farmers in Central Europe

After the negation of the Carnairo-hypothesis, absolute subsistence limits (availability of arable land) in relation to the incidence of inter-community conflict cannot be seen as generally determinative. However, raiding and warfare may still promote, or be promoted by factors definable after archaeological evidence. "Conflict phases" between agrarian communities in later prehistoric Central Europe are thus designated as to mode and focus of conflict in relation to factors of reconstructed population levels and means of socio-political integration so as to help define the cultural context of direct competition through time.

Table 14.6. Modes of conflict and socio-politcal integration among agrarian communities

Time period	*Mode of social integration*	*Mode of conflict*
1. Middle Eneolithic	Tribal-segmentary (under higher local population density)	Raiding
2. Classical Early Bronze Age	Tribal-segmentary (under high population density) and (emergent) regional polities (Pannonia only)	Raiding with cultic-ideological focus
3. Early Urnfield Bronze Age	Regional polities replacing tribal segments (under high regional population density)	Raiding or warfare with cultic-ideological focus
4. Middle La Tène Iron Age	Linear (?) tribal segments	Inter-tribal warfare
5. Marcomannic Wars	Aggregated linear (?) tribal segments	Inter-polity warfare

Respecting observable regularities, Periods 1 to 3 reflect conditions of high population density and increased kin-distance (vis à vis neighbouring local groups). Local groups of these periods are initially oriented upon Big Man leaders (e.g. Fig. 88, 96). After the establishment of ranked regional polities, peaceful relations are engendered amongst peer-polities (during Periods 2-3, cf. Figs. 99, 114-115, 110). This pacification is defined in Period 2 by a horizon of de-fortification of central fortified sites which transpires during the Classical Phase of the Mad'arovce Culture in West Slovakia, even as the first hill-forts (of Late Únětice date) are established in (socio-politically less-complex) Bohemia.

Period 3 pacification follows the establishment phase of the Urnfield Culture, a sub-phase earlier in Moravia (after Blučina-Cezavy), and perhaps in East Bohemia (after Velim) than in Central and West Bohemia (after Prague-Modřany and Žatec I). Early sword-equipped mound burials follow the same east to west chrono-spatial patterning, after Reinecke C2/D finds from Velké Hostěrády Mound I (inhumation grave). Slightly later (Reinecke Phase D) Mound III (cremation grave) produces the first full-Urnfield assemblage, including three bi-conical vases (a key type), as well as a bronze sword, spear and dagger combination. Although no such graves occur in the Early Lusatian Culture, Knovíz warrior (cremation) graves in burial mounds in Bohemia date to Phase D or Hallstatt A1 (e.g., at Žatec and Milavče), coeval with the majority of Knovíz finds of inhumed skeletons in settlement features. Where analysed, these latter Knovíz finds often bear traces of para-mortal impacts. Together with the establishment phase mass-inhumation mortuary cults at Blučina and Velim, a horizon of intensive tribal warfare (with a cultic and social symbolic focus) is thus traced at the beginning of the Urnfield sequence. Significantly, all 80 Bohemian Urnfield settlements known to contain inhumed skeletal material belong to the Upper Danubian Knovíz rather than the boreal Lusatian Culture.

An early phase of hill-fort construction among the Danubians of the Velatice and Knovíz Cultures is similarly non-evident in Lusatia except in emergent cultural boundary zones (e.g. at Velim, cf. Fig. 113). Generally, Lusatian hill-fort development is retarded until its Silesian (Hallstatt B) phase. Apparently, less centralised socio-political relations are maintained in this boreal cultural zone, as Lusatian hill-forts are oriented towards Danubian boundary zones rather than centres of cultural settlement. This (archaeological) cultural linkage of warfare and socio-political modes across bio-geographic boundaries, against a background of general demographic growth underlines the culturally relative rather than naturally determinative nature of vectors promoting warfare or "direct competition" between Bronze Age agrarian communities in Central Europe.

It is possible then that the establishment of kin relations between leading clans of consequent Urnfield regional polities serves to suppress "effective" (but not "symbolic") aggression, as leading clans establish mutualistic inter-regional ties. For example, if only 20-30 individuals of leading clan segments of emergent regional polities derive from any one polity (i.e., 2-3% of the regional population), one might conclude that an "elite inter-action sphere" of 1-2,000 km^2 will be required to provide a viable inter-marriage network (of 500 individuals) for ranked systemic maintenance. This macro-territorial estimate follows after discrete regional polity territorial ranges of 50 (lowland) to 100 (upland) km^2 in the Late Bronze Age of Central Germany, as reconstructed by Wagner and Simon (Fig. 114). This projected macro-sphere of 20-30 regional polities may have diffuse or fluctuating boundaries, producing diffuse distributions of ornate metal artifact types which cross-cut ceramic cultural zones in the Urnfield period. Importantly, typological sets of (martial and ornamental) bronze artifacts of the Urnfield establishment phase (Reinecke Bronze Age C/D) of upland Franconia (Eastern Bavaria) do form discrete regional distribution ranges in the order of 100 km^2, or the expected area bounded by an emergent Urnfield regional polity in the Central European upland zone.[4] This regional particularism dissipates after Reinecke Bronze Age D, perhaps with the full establishment of ranked clans and a consequent elite inter-action sphere of symbolic artifact exchange.

The specific expression of raiding or warfare during the Bronze Age is oriented upon "ideologically structured" activities which bear upon individual status or an enigmatic cultic focus. In the Early Bronze Age (Period 2), an attribution of individual "coups" is reflected in the use of human skulls as grave goods in weaponry graves (e.g. at Blšany), a spate of grave robbery in Classical Early Bronze Age Pannonia (which includes the taking of skulls from individual graves, e.g. at Mušov) and the haphazard deposition of human remains in settlement pits (e.g., Fig. 100). The latter remains often bear traces of para-mortal impacts, and are known from 35 Únětice sites in Moravia (Moucha Phase 5 primarily) and 20 sites in Bohemia (Moucha Phase 6 primarily). Once again, an "orientalising" chrono-spatial pattern of the conflict horizon is discernible which has material cultural analogues in the presence of isolated Věteřov types at Late Únětice (Phase 6 of Moucha) sites in Bohemia.[5] A more wide-spread and larger

4 Cf. Berger 1984, Simon 1984, Wagner 1992

5 Militký n.d., M. Kuna pers. comm. 1995

scale expression of similar hostilities reemerges after a Middle Bronze Age hiatus, with the Period 3 (Late Bronze Age) conflict horizon following with the diffusion of Early Urnfield material cultural elements.

Empirically, this "competetive-aggressive" social or behavioural trait would appear to be favoured in the context of unranked societies under high population densities, or at the interface of specific social transformation phases (i.e., from simple tribe to regional polity). Potentially, social aspirations which promote this trait are made moot by the establishment of a more permanent hierarchy of ranked lineages, although symbolic expression of aggression might continue, for example with the highly evolved, and yet demonstrably ineffective Urnfield panoply. Spatial restriction of kin groupings is then positively correlated with effective warfare in both contexts, in that one ultimate effect of the establishment of higher orders of socio-political integration is to transpose over wider areas a decision-making elite which by population reproductive necessity maintains a primary social group of *circa* 500 individuals.[6]

More effective (wrought-iron) weaponry forms then evolve with the (partial?) devolution of the Urnfield socio-political system in Hallstatt C. The production of iron ornaments and personal effects already in Hallstatt B in Central Europe suggests that this development of more-effective armaments is induced by destablising socio-political conditions rather than mere technological opportunism. A renewed focus on burial wealth then anticipates the reformation of regional polities of Danubia in Hallstatt D (e.g., see Figs. 125-126).

Periods 4 to 5 then reflect conditions of more boundary-oriented inter-tribal and inter-political warfare of the Late Pre-Roman and Early Roman Iron Ages. This "higher-order" warfare is reflected in data patterns both subtle and obvious. Subtle patterns arise in the case of Period 4 (Middle La Tène), when a high incidence (2+%) of para-mortal violence is detectable on human skeletal material from ritual inhumations along the southeastern periphery of the La Tène Culture (in Southwest Slovakia). The incidence of secondary female "slave-graves" in South Moravia reinforces this perception of special cultural boundary conditions which are distinct from those of the La Tène core cultural zone (cf. Fig. 131).

Hypothetically assuming closer kin relations within cultural distribution zones and distant relations at cultural boundaries (cf. Chapter 2), this pattern is conformative with conditions of linear segmentary tribal warfare, whereby relative kin-reckoning through unranked linear segments determines aggressive or passive attitudes towards neighbouring local groups or

6 Kosse 1990, 1994

polities, as for example among the Tiv and Nuer.[7] This ethnography-dependent hypothesis recalls Strabo's specific employment of the relative "neighbour" term ("πλησιον") in describing the focus of war band muster among the La Tène Age tribal "Galatians and those who are called Galatians" ("τε και Γαλατικον καλουσι", note Strabo's critical ethnic qualifier).

Less subtle is the proto-historic evidence for the Marcomannic Wars of the terminal Early Roman period (5) discussed at length in Chapter 12. In this period (AD 166-180), it is important to remember that collective barbarian war bands mustering in the lower thousands are recorded by Dio and require the attention of a full legion from Brigetio, suggestive of integrated (multi-linear?) tribal segments amongst the so-called "Germanics". Not unlike the proposed Vekerzug Horizon, acute subsistence concerns stemming from a later 2nd Century agricultural crisis might have induced Ballomar, the ten "kings" and their war bands to despoil the Roman provinces, bringing on a reactive imperial-political retribution. Perhaps as an expression of the relative competetive exclusionary principle in relation to such pressures of raiding and warfare as outlined above, progressively larger political units emerge in later prehistory:

Table 14.7. Development of regional polities in later prehistoric Central Europe

Time period	*Polity population*	*Political mode*
Classical Early Bronze Age (Pannonia)	1,100 (Nitra)	emergent regional polity
Late Bronze Age	1,300 (Roztoky)	stable regional polity
Late Hallstatt Iron Age	1,300 (Hradec-Kadaň)	stable regional polity
Late La Tène Iron Age	5-10,000 (Oppida)	unstable inter-regional polity
Early Roman Iron Age	1,400 (x10 segments)	aggregate (multi-linear?) regional polities

Note that the Late La Tène range assumes macro-site (Oppidum or Lovosice-site) populations of 2-4,000 plus an inclusion of a hamlet-based macro-regional population base (cf. Figs. 133-134). The Early Roman segmentary multiplier (after Cassius Dio) refers to tribal-martial mustering potential.

Hypothetically, the ultimate tendency in the evolution of tribal political systems is to maximise

7 Sahlins 1961, 1968

military potential with a minimal logistical investment in "top heavy" socio-political structures. However, these larger, higher order political systems succeed not because of higher mean fitness imparted to their participants; merely their integrated-size is sufficient to ensure "political exclusionary success". In addition to other factors, upper size-limit thresholds of regional polities reflect equilibrium (no "victor") conditions in the competetive exclusionary outcome matrix. This equilibrium is presumably achieved by means of cultural convergence of adjacent tribal units towards similar scalar levels of political integration and (sometimes without political integration) the erection of physical defenses which reduce the combative advantage of potential aggressors. Proximate material or ideological conditions for the crossing of political thresholds (e.g., local Big-man to regional polity modes of integration) might be quite variable.

These social systems, both higher and lower order, are sensitive to systemic stress as imposed by extrinsic limiting factors such as climatic minima and the intrusion of alien cultural elements. These systemic limits on general population density are apparently of sufficient magnitude and frequency so as to truncate any demographically led development of stable, complex socio-political units above the regional polity level in later prehistoric Central Europe.

Exceptional then is the rapid rise of the inter-regional Late La Tène macro-site system. The enigmatic fall of this system within a century-and-a-half of its inception might reflect the intrinsic inefficiency of top-heavy socio-political systems which fail to generate generally adaptive "special functions" or new cultural variety. Recall then the material- and ideological-functional redundancy of Oppida vis à vis lowland hamlet communities of the Late Iron Age (e.g., Fig. 130). Particularistically, these Oppida may reflect "politically-stimulated" settlements, promoted by the reintegration of (politically transformed) Galatian war bands returning from their mercenary service with Hellenistic archaic state systems. In contrast, smaller tribal populations of the Púchov Culture maintain archaic political and subsistence modes until Roman times. Possibly, this enclave survives in highland areas which enhance its co-efficient of competetive exclusion in terms of defense, thus compensating for its lower integrated population levels in group defense and ensuring its persistence until the Marcomannic War period.

Potentially, higher levels of tribal or political warfare (i.e., above the level of individually motivated raiding) may also condition the definition of somatic adaptation, making this relationship more dependent on group defense than on optimal group subsistence. A comparative test of the reflection of archaeological cultures as systems of subsistence adaptation will now follow after the comprehensive natural and cultural historical data.

Ideological adaptation is assumed to be culturally conditioned, so that constraints on individuals as imposed by cultural filters and the quality or quantity of information flow may impair fitness. The cultural boundedness of adaptive systems may be expressed by differential adaptive success, measured demographically between distinct cultural units. Hypothetical expressions of these cognitive limiting factors are now reiterated.

Cultural Hypothesis A: Differential adaptation will lead to the diffusion of populations participating in adaptive systems more in conformity with their environment. Because adaptive systems are conformative to a limited range environmental variability, as environmental change transforms the adaptive context, systems pre-adapted to emergent ecological conditions will be demographically favoured. This differential adaptive success will be expressed in the infiltration of populations from pre-adapted zones, or through cultural ecological convergence on the part of sub-optimally adapted populations. If archaeological cultures are linked to these somatic adaptive systems as indirect indices of effective information exchange, the directionality of material cultural influence will follow that of climatic shifts. Thus Hercynian (mini-max adapted) cultures will be favoured by climatic minima, while Pannonian (optimising) cultures will be favoured by climatic maxima.

Cultural Hypothesis B: In general, demographic growth will tend to restrict kin-dependent networks of information exchange as mean mating distance lessens, unless these cognitive networks are superseded by wider social (and informational) exchange networks engendered by the emergence of higher orders of socio-political integration (e.g., linear tribal systems). The cultural landscape will tend to variegate into a mosaic of units in tandem with demographic growth, if localised kin relations represent the primary channel of information flow.

Diffusional "directionality" has been defined after cultural, sub-cultural, typological and attribute diffusion after Cultural Hypothesis A, and is compared to climatic tendency. Cultural Hypothesis B will be tested by means of comparing cultural geographic patterns of relative variegation. The notion of cultural variegation in Table 14.8 relies on a geographic assessment of culture group, major or minor culture and cultural enclave distribution in the principal study region of Bohemia, Moravia and West Slovakia. Note that the cultural variegation index is cumulatively assessed on the basis of principal study area presence of: cultural groups (value=1.5, e.g. Věteřov-Mad'arovce and Bylany-Horákov-South Bohemian Tumulus group); major cultures (value=1.0, e.g. Řivnáč, Corded Ware and Knovíz Cultures); minor cultural units (value=0.5, e.g. Jordanov, Michelsberg, Globular Amphora, Carpathian Tumulus Culture and Przeworsk) and regional enclaves (value=0.25, e.g. Turnov Type, Púchov Culture and "Kostolec Group"). Arbitrary regional cultural terms are discarded, thus a nominal ascription of culture-level differences between the Věteřov-Mad'arovce Groups is ignored and these are treated as a single group. In this case, a culture group designation lowers the index from 2.0 to 1.5, indicative of greater trans-spatial similarity of material cultural entities. Generally then, lower variegation values will roughly reflect a greater cultural similarity over space within the principal study region. Cultural Hypotheses A and B are now compared against a range of cultural and natural historical tendencies emergent between the Eneolithic and Migration periods:

Table 14.9. Cultural geography compared with summary climatic and demographic data patterns

Time period	*Variegation index*	*Site structure*	*Directionality*	*Climate*
1. Early Eneolithic	2.0	hamlet	Hercynian	Min. I
2. Middle Eneolithic	4.5	village	Pannonian	Max. I
3. Late Eneolithic	1.5	household?	Hercynian	Min. I
4. Terminal Eneolithic	1.5	household	Neutral	Min. I-Trans.
5. Earliest Bronze Age	2.0	hamlet	Neutral	Trans.
6. Classical Early Bronze Age	2.5	village-hill-fort	Pannonian	Max. I
7. Middle Bronze Age	1.5	hamlet	Hercynian	Min. II
8. Early Urnfield Bronze Age	3.0	village-hill-fort	Pannonian	Max. II
9. Late Urnfield Bronze Age	4.0	village-hill-fort	Neutral	Max. I
10. Hallstatt C Iron Age	2.5	hamlet-village	Pannonian	Min. I-Trans.
11. Hallstatt D/La Tène A	2.5	village-hill-fort	Pannonian	Max. I
12. Middle La Tène Iron Age	1.5	hamlet	Hercynian	Min. II
13. Late La Tène Iron Age	1.25	hamlet-Oppidum	Neutral	Min. I-Trans.
14. Early Roman Iron Age	1.25	hamlet-village	Hercynian	Max. I
15. Late Roman Iron Age	1.75	hamlet	Hercynian	Min. I

A periodic synopsis of the above (1-15) cultural geographic tendencies follows:

Period 1: Southward diffusion of Baalberg Group (stages B 1b onward in South Moravia).
Period 2: Northward diffusion of Channeled Ware (appears later in East Bohemia, with Kamýk sub-phase), with evolution of Řívnač Culture upon this substrate (with further cultural diffusion towards West Bohemia). Jevišovice Culture in South Moravia introduces further southern (Vučedol) decorative attributes from North Balkans.
Period 3: Southeastward diffusion of Corded Ware Culture, Horizons I and II barely represented in Moravia, Horizon I demonstrably coeval with "terminal" Jevišovice Culture in South Moravia, where a Pannonian-influenced mixed cultural zone emerges in Horizon IIIb/c.
Period 4: Cosmopolitan origins of attributes and types of formative Bell Beaker Culture, a mixed culture zone can still be recognised in South Moravia, incorporating Kosihy-Čaka types with the Bell Beaker Begleitkeramik.
Period 5: Regionalised evolution of Únětice Culture from a Late Bell Beaker Begleitkeramik substrate. Note the disjunctive appearance of Chłopice-Veselé Group in West Slovakia.
Period 6: Northward diffusion of individual Věteřov types into Bohemia. A "reduced-range" Věteřov group can also be defined in the environs of Hradec Králové in East Bohemia.
Period 7: Regionalised evolution of Tumulus Cultures.
Period 8: Northward diffusion of Urnfield Cultures or individual Urnfield types, including the bi-conical vase and other ceramic types, the cremation rite, bronze weapon and ornament types, as well as wheel or sun designs, bird protomes and other symbolic attributes on cultic artifacts. Substrate "interference" is greater in Lusatia (i.e. Tumulus Culture types and attributes exhibit continuity). The "Milavče Culture" in South Bohemia is treated as part of Knovíz Culture.
Period 9: Regional variegation of Urnfield Cultures, including emergence of an East Bavarian-influenced Nynice Group in Southwest Bohemia after a Hallstatt B1 cultural disjunction.
Period 10: Painted pottery attributes diffuse from Nynice substrate (becoming South Bohemian Tumulus Culture in Hallstatt C) to Bohemia and Moravia (on Štítary and Podolí substrates).
Period 11: Late (Stage D) development of pre-established Hallstatt cultures and appearance of Vekerzug Culture elements on the emergent Pannonian steppe. Note also the appearance in the Lusatian Platěnice Group of Danubian type chamber graves and Danubian decorative attributes (triscle, wheel and sun symbols) on indigenous pottery types, in Hallstatt C/D.

Period 12: Southward diffusion of highly cohesive La Tène Culture. Multi-directional cultural expansion of this is traced outside principal study area. Púchov and Turnov enclaves emerge.

Period 13: Continuity of La Tène Culture unity across West and Central Europe. Lowland Turnov enclave is absorbed early in this period.

Period 14: Southward transformative diffusion of faceted-rim ("Germanic") pottery groups which replace cohesive La Tène Culture. The upland Púchov enclave persists.

Period 15: Appearance of regional minor cultural elements or regional enclaves of boreal origin. The Púchov enclave is absorbed at the beginning of this proto-historic period (ca. AD 180).

Two major stages of adaptive meaning vis à vis archaeological cultures might be inferred on the basis of this comparison of summary cultural historical data of diffusion and variegation vis à vis factors of climate and population. Of the A-Hypothesis (of climate-cultural diffusion linkage), a near perfect positive relationship is expressed between agro-climatic and cultural geographic tendencies until Period 9 (Late Urnfield). Of the B-Hypothesis (of population-cultural variegation linkage), a near perfect positive relationship is expressed between site population structures and cultural variegation until Period 10 (Hallstatt C), after which the pattern is ambiguous.

This latter difference suggests that information flow in later stage tribal culture is dictated significantly by extra-local population dynamics, the latter of which are modulated by systems of social complexity (elite-interaction) or more linear networks of kin relations in less-complex social situations. Early *vs.* late stage differences in the adaptive meaning of cultures can then be inferred after the later (non-) alignment of cultural patterns with natural equilibria. In their Pre-Urnfield stage, cultures may reflect adaptive systems oriented upon subsistence and more localised kin networks, while later stage cultures are oriented upon more extensive kin networks in a milieu in which cultural cohesiveness and continuity is more dependent on collective defense than on subsistence adaptation. Notably, demonstrable deviations from expectations of the Climatic hypothesis are also limited to the post-Urnfield period.

Archaeological cultures and early vs. late subsistence patterns

These summary data thus suggest that early stage (pre-Late Urnfield) cultures may reflect effective analytical units of convergent subsistence adaptational information exchange. Early

Eneolithic to earlier Bronze Age patterns of crop use are interesting in this light in that these usually reflect ecologically rather than culturally linked factors. During the Eneolithic for example, an increase in the use of barley (more cold-resistant than emmer wheat) in Central Europe, and its enhanced employment in colder, more boreal zones may be noted. The degree to which Eneolithic cultures reflect subsistence adaptive information systems might then be related to the pastoral (mini-max) *vs.* arable (optimiser) balance in the agricultural economy. For example, a high frequency of quern stones on Middle Eneolithic sites might reflect the "optimising" (arable-favoured) character of agriculture during this warm period.[8] Then during the Early Bronze Age, bread wheat (a narrowly edaphic, but most productive crop) becomes most common on sites of the Mad'arovce Culture, sites which also contain high reconstructed population levels. An optimising agricultural strategy leading to this demographic condition is promoted by moderately warmer climes of the Early Bronze Age.

Conversely, a definitively cultural rather than ecologic association of particular cultigens first occurs in the Urnfield Bronze Age, as expressed by the exclusive cultivation of spelt wheat by Lusatian farmers. The edaphic qualities of this strain in sub-xeric agro-climates is not recognised by Middle Danubian communities in the dry lowlands of West Slovakia. This failure may reflect the laterally restrictive nature of verticalised information networks of "more complex" Danubian polities, networks which reduce the flow of information from more segmentary societies with weaker elite-interactive links.[9] Less exclusive is the linkage of oat cultivation with the La Tène Culture, although in this instance, the agricultural norm of *Avena* cultivation is associated with a particular culture whose polythetic linguistic make-up is at least part-Celtic (note the agronomic-syntactical prominence of *A. sativa* in Old Gaelic). During the Roman Iron Age, *A. sativa* is is still twice as common in Bohemia (former La Tène core area) as in Slovakia (former periphery), carrying this association residually with the emergence of new cultural entities. During this post-Urnfield tribal stage, arable strains seem to be less-evenly distributed over space due to disjunctive boundary conditions imposed by transforms of tribal organisation (note that pattern deviations from the Climatic hypothesis also occur in this period).

8 A low frequency of of quern stones might be cited from the Baalberg-Salzmünde occupation of Prague-Baba, where three *metates* fragments were recovered from an artifact collection of 40,000. Most of the 28 ground stone artifacts here appear to be whet-stones for ax-grinding. A collection some 150% larger from Middle Eneolithic Homolka produces nearly complete *metates* from 11 and fragments from 14 features (not including finds from the general culture layer). More than 100 *manos* were recovered from Homolka, up to seven per hut unit.

9 Butzer (1993) cites an analogous case of the differential use of spelt wheat in the context of Carolingian agriculture, whereby the economy of large (elite) estates (optimiser oriented) is based on steno-edaphic bread wheat and meso-edaphic barley, while small (peasant) estates (mini-max oriented) rely largely on spelt (widely edaphic, but less productive under optimal conditions). Large and small estates thus function as two separate economic sub-cultures.

Lower cultural variegation is also achieved under higher population densities due to these same socio-political or linear kinship factors (information exchange transcends local systems).

Bilateral cultural ecology of early stage social adaptations

Significantly, it is inferred that in their pre-Iron Age state, simple tribal societies of Central Europe produce extensive evidence of raiding or warfare under higher population densities, particularly when these periods anticipate the attainment of higher levels of population integration. These latter levels are dependent not only on dia-chronic population growth, but also on the spatial scope of tribal integration. It is suggested that such direct competition is modulated by factors of socio-political integration rather than immediate material factors. As tribal populations reach a (ca.) 1000 level, disequilibrium states of variant manifestations can be expected, of which mortuary evidence for social ranking and warfare are two archaeologically visible effects. Transforms of individual social status might then be particularly possible during such socio-political transitions anticipating socio-politcal complexity, leading to a most-emphatic expression of burial wealth at the establishment phase of regional polity formation.

Socially cohesive rule by resultant vertically transposed higher ranking individuals is also limited by the reproductive constraints of minimal mating networks, networks of (ca.) 500 individuals which in turn necessitate the establishment of stable inter-regional socio-political relations. One can then view the suppression of effective warfare in the Late Bronze Age regional polity mosaic as the regulation of population level-dependent disequilibria (warfare) by virtue of yet another facet of population biology. Bilateral population biology, encompassing subsistence and warfare on one hand, and limits of mating networks on the other, is thus sufficient to explain all social adaptations to population as an independent variable, once simple models of population biology account for complexities of the cognitive condition (see below).

Late stage transforms of somatic adaptation

The (later stage) Iron Age break-down of association between natural (climate and population density) and cultural historical tendencies might be explained in various ways (cf. Table 14.8). Firstly, higher order systems of socio-political integration emerging from the Urnfield period might impose super-ordinant networks of information exchange which over-ride those linked with more-localised, segmentary population networks. Secondly, the emergence of larger (and more?) linear tribal units might also impose strong "selective pressures" for the promotion of larger political systems *per se*, regardless of the mean populational fitness of individuals within these systems. This difference also transforms the relationship between cultural diffusion and adaptation to one more dependent on "direct competition" (warfare) than "optimal farming".

If for example, adaptive benefits of an individual's membership in tribal groups of greater martial effectiveness outweighs the differential adaptational potential of culturally variant subsistence strategies as discussed in the above section, then the expansion of such groups will be favoured in the inter-tribal group context where inter- rather than intra-tribal group warfare is prevalent. The cultural-historical effects of such direct competition will be visible (as culture expansion) only where inter-cultural differences align with boundaries of such tribal groups.

Assuming then that the latter tribal groups are linear, traces of warfare will appear most prevalently on cultural boundaries, with very little direct evidence of such in the cultural core area. Thus the La Tène case scenario is characterised by socio-political equilibrium at its centre, although the reflection of La Tène culture bearers in Classical sources may describe these tribals in their disequilibrium (boundary), and hence, more aggressive socio-political state.

It is also possible to characterise (archaic) state-level societies such as Rome as intentionally influential towards border tribals, transforming the socio-political relations of the latter through an incorporation into the Roman client-king system. This system of diplomatic relations with Roman-imposed chiefs is reflected archaeologically in the princely grave phenomenon, a limited mortuary complex which seems culturally disjunctive in the context of a generally modest native expression of burial wealth (cf. Fig. 137). In essence, this diplomatic system regulates peace at the northern limits of the Roman state, in addition to providing a platform for predatory imperial expansion beyond these limits. Should Central European peoples of the Early Roman period also be seen as quasi-linear in their tribal structure, outward expression of aggression towards the Roman boundary area will then be promoted by the principle of complimentary opposition. The potential disequilibrium of Roman border conditions thus gives rise to a reactive-aggressive socio-political state among tribals which might otherwise be at peaceful, stable equilibrium.

Bilateral cognitive adaptation

Human cognition has modified most aspects of somatic adaptation, first in the act of creation of a farming ecology itself, specifically at steady-state equilibrium (rather than natural, stable equilibrium). This state of the agricultural system requires constant labour in-put, as well as in-puts of technological and domesticate-biological variety for systemic sustenance. Likewise, the anticipation of advantages of martial-political integration in the context of tribal warfare reflects a cognitive transformation of simple ecologic principles of competetive exclusion (see above).

Due to intrinsic cognitive linkages, least modified of these adaptive principles is the minimal mating network. Linked with limits in the long-term memory, a replication of a multiplicity of primary social groups of (ca.) 500 reflects the long-term (lag) effects of natural selection on low-density hunter-gatherers, effects which are out-of-equilibrium with higher population levels in agricultural society. In complex society, a verticalised division of population into primary sub-segments of (ca.) 500 might thus be seen to reflect a necessary reestablishment of quasi-egalitarian (in-group) social relations in conformity with cognitive limits of the individual long-term memory. Thus in class society, great inter-segment inequality is often contradictively expressed as in-group equality, for example, in the Archaic Spartan social term οι ομοιοι. Out-group inequality is expressed by material symbols which may also be archaeologically visible.

Table 14.9 Cognitively-modulated expressions of ecological principles in agricultural society

Ecologic model	*Agrarian society adaptation*	*Archaeologic expression*
I.A. Optimal foraging theory (somatic-subsistence)	Optimal farming theory, with agro-climatic reduction of K capacities leading to adaptive adjustments in agriculture or development of new crops.	Shift in the balance to and from arable and pastoral agriculture, expansion of variety of cultigen macro-fossils, evidence for use of ard, iron sickle and plough.
I.B. Competetive exclusion (somatic-direct competition)	Raiding or warfare, integrated rather than gross population levels operative after Lotka.	Settlement evidence for regional polities, erection of defenses, development of wrought-iron weaponry and horse-riding.
II. Optimal mating theory (reduction of mean mating distance)	As per ecologic model, with vertically transposed mating networks in complex society.	Inter-regional elite exchange networks mirror kin networks of vertically transposed segments.

Later prehistoric farming communities are not only limited by natural environment, but also limit ecologic productivity through the perturbation of natural equilibrium states. In some parts of Central Europe, these perturbations are sometimes of sufficient magnitude so as to reduce the environment permanently to a lower productivity (*K* capacity) equilibrium.

With respect to lowered agricultural *K* capacities, human transformation of the natural environment might be invoked in the general Hercynian material cultural influence which prevails in Pannonia after the Hallstatt D period, irrespective of climatic tendency. This terminal cultural influence might indirectly reflect an anthropogenic denudation and depopulation of the Carpathian Basin. This anthropogenic denudation is expressed florally in irreversible woodland clearance and dry steppe formation from wet pasture. The importance of anthropogenic impacts in this steppification process is suggested in the association of settlement loci with czernozem and rendzina pedogenesis during the Bronze Age. Particularly profound changes in relative soil moisture levels indicated in Urnfield period pedogenisis may accord with changes in growing season temperatures, but <u>not</u> with reconstructions of somewhat greater evapo-transpiration potentials after COHMAP data. A somewhat greater atmospheric moisture availability reconstructed by COHMAP for the Urnfield period is thus indicative of a proximate importance of human agency in the deforestation of the continental Pannonian zone. An <u>artificial</u> increase in soil moisture-loss through human land-use is strongly suggested.

Conversely, Hercynia proves more robust in its maintenance of a woodland mosaic as well as a higher potential for dry agricultural productivity. As general environmental *K* capacities in Pannonia decline absolutely, the demographic centre-of-gravity thus shifts towards the less degraded Hercynian bio-geographic zone, reducing population densities in the former zone and increasing the demographic "migration by infiltration" potential of the latter region towards Pannonia (i.e., there are more "empty spaces" which may be potentially filled on a periodic basis in the steppe zone relative to the temperate zone in latest prehistory and proto-history).[10]

The demographic effects of these anthropogenically altered natural limits may be seen in site population reconstructions (cf. Tables 9.1, 10.1 and 11.1), whereby individual pre-Hallstatt D site populations are generally greater in Pannonia vis à vis Hercynia. This reconstructed settlement population differential is at its highest levels in the Eneolithic and Early Bronze Age periods. Relative population densities between the two bio-geographic zones then equalise

10. Neustupný 1982

during the Late Bronze and Early Iron Ages.

By Early Roman times, large tracts of the Hungarian Plain are sparsely occupied by nomadic pastoralists while temperate Bohemia supports a dense farming population as attested in both archaeological and Classical sources. Two thousand years earlier in the Classical Early Bronze Age, Pannonia and the northern rim of the Carpathian Basin had in contrast supported relatively dense agrarian communities in what were probably the first regional polities of Central Europe.

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