UNIVERSITY OF SOUTH BOHEMIA IN ČESKÉ BUDĚJOVICE
FACULTY OF ARTS
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MASTER’S THESIS

# PARAMETERS OF THE SETTLEMENT ACTIVITY OF THE LOWER OHŘE AREA BASED ON EXTENSIVE SURFACE ARTEFACT COLLECTION IN COMPARISON WITH THE GENERAL ARCHAEOLOGICAL RECORD

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**Declaration**

I declare that I am the author of the presented qualification thesis and that I have composed the thesis solely using the sources and publications referred in the list of used sources.

In Hradec Králové 30th July 2021 Martina Vasiľová

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## Annotation

The presented work is based on surface artefact collection of the northern transect of the ALRNB programme undertaken over the first half of the 1990s. The study area located in north-western Bohemia is delimited by a transect of 13 by 32 km. The results of the ALRNB programme are compared to the general archaeological record represented by AMČR database. Attention is focused on the theory and history of surface artefact collection and publications concerning the ALRNB programme. Later chapters include characterisation of the ALRNB and AMČR record. Aoristic analysis and Monte Carlo simulation are utilised to analyse temporal distribution. Modelled distribution is used to evaluate selected environmental factors and continuity of settlement activity.

Key words: surface artefact collection, ALRNB programme, north-western Bohemia, landscape

## Anotácia

Predkladaná práca je založená na povrchovom zbere zo severného transektu programu ALRNB, ktorý bol realizovaný v prvej polovici 90. rokov minulého storočia. Záujmové územie lokalizované v severozápadných Čechách je vymedzené transektom 13 x 32 km. Výsledky programu ALRNB sú porovnané s obecným archeologickým záznamom reprezentovaným databázou AMČR. Pozornosť je zameraná na teóriu a históriu povrchových zberov a publikácie týkajúce sa programu ALRNB. Neskoršie kapitoly obsahujú charakterizáciu dát z ALRNB a databázy AMČR. Na analýzu časovej distribúcie je využitá aoristická analýza a simulácia Monte Carlo. Modelovaná distribúcia je využitá na vyhodnotenie vybraných environmentálnych faktorov a kontinuity sídelných aktivít.

Kľúčové slová: povrchový zber, program ALRNB, severozápadné Čechy, krajina

**Contents**

## 1. Introduction

The core of the presented work is based on the surface artefact collection of the northern transect of the ALRNB – Ancient Landscape Reconstruction in Northern Bohemia programme. The aims of the work, however, do not fully overlap with the original aims of ALRNB. Additionally, the study area was modified compared to the original transect.

Within the whole ALRNB programme, two transects were surveyed. Results from the central transect were published in the 1990s and 2000s and the data were also used in more recent studies. The results from the norther transect, on the other hand, remained largely unpublished. The only exception is the paper by R. Křivánek (2012), which focuses on the Vraný micro-region.

Initially, the ALRNB programme aspired to utilise a broader range of non-destructive survey methods, to cover areas outside of current arable land, however only surface artefact collection was applied at larger scale. The methodological framework, theory, and development of use of artefact surface collection in the Czech Republic and Slovakia are included in Chapter 4 of this work.

The general archaeological record was gained from the Czech national archaeological database: Archaeological Map of the Czech Republic (Archeologická Mapa České republiky) – AMČR. AMČR includes records of archaeological fieldwork independent of the methods used. An onlook at the AMČR dataset demonstrates some of the present research biases such as change in localisation accuracy, prevalent fieldwork methods and ratio of recorded past activities. Although AMČR data included components located in higher elevations, including the Hradišťany hilltop settlement in the extreme location within the studied area, the coverage is not even.

For compatibility and to reduce impact of the unevenness of research, locations from both datasets were converted into a square grid, where only presence or absence of a component within a grid square was further considered. This approach had been applied within Czech archaeology both to reduce bias in the record (Kuna 2015b) and to compare records unpubligained by different methods (Dreslerová – Demján 2019).

In accord with current trends of landscape archaeology, in order to better incorporate the continual nature of temporal dimension, aoristic analysis and Monte Carlo simulation were used to model temporal distribution of the recorded past activities. Aoristic analysis operates with uniform probability redistributed by the length of the dating interval. Monte Carlo simulation enables the assessment of varying uncertainty caused by varying volume and temporal accuracy of record, and measurement of the significance of change.

Modelled temporal distribution was further used to consider selected environmental factors. Average elevation, distance from the nearest water source and relation to present day soils were examined. Additionally, continuity of settlement was considered.

## 1.1 Aims

The main aims of the thesis were evaluation, visualization, and interpretation of the database of the northern transect of the ALRNB programme gained by surface artefact collection, and analysis and comparison of the informative value of ALRNB collections against the general archaeological data and the expected intensity of settlement. Objectives included search of literature concerning surface artefact collection and summarization of the previously published literature concerning the ALRNB programme.

## 1.2 Temporal delimitation

The temporal focus of this thesis was delimited by agricultural prehistory and EMA. Within the ALRNB programme, finds predominately represented by pottery sherds from Neolithic to the 20th century were collected. However, durable HMA and later pottery recorded by surface artefact collection is generally considered to represent specific cultural and postdepositional processes (more in Chapter 4) and in this work it was considered only to a limited degree for the ALRNB record. Records from earlier and later periods from general archaeological records represented by AMČR were not included.

## 1.3 Study area

The narrowed study area of this work was based on the position of ALRNB polygons in the original northern transect. The northern, sparsely surveyed part of the original transect, was excluded due to significant terrain and landscape changes caused by recent coal mining and resulting limitations of available environmental data. The new area (Fig. 1.1) was delimited by a rectangle of ca. 13 by 32 km (XY coordinates in

S-JTSK: -778477,919, -985393,768; -756555,276, -1008928,37; -766035,241, -1017759,02; -787957,885 -994224,421).

Subdivision into geomorphological units places roughly a third of the study area in the northwest of the mountain range of České středohoří (subsystem Podkrušnohorská podsoustava). The southeastern part belongs to the plateau of Dolnooharská tabule (subsystem Středočeská tabule) (Mackovčin et al. 2009).

The most significant river in the area is Ohře. The whole area belongs to the North Sea drainage.

Geological setting of the area is dominated by claystones, marlstones, sandstones and limestones with the presence of volcanites in the northwestern part (Cháb et al. 2009).

The digital terrain model (with 2 m horizontal resolution and vertical accuracy + / - 0.3 m, referencing Baltic Vertical Datum) places the elevation of the area between 157 and 752 metres above sea level (Fig. 1.2) with the median of 274 and mean of 289 metres (ČÚZK a [online]). The highest elevation belongs to the Hradišťany hilltop of České středohoří mountain range, the lowest to the lower Ohře area.

The study area includes four of contemporary climatic regions: cold, moderately warm, warm with low precipitation and very warm with low precipitation. The cold region has an average temperature of 12–13 °C in summer and below - 4 °C in winter, the moderately warm 13–15 °C in summer and - 2 to - 3 °C in winter. For the warm region, average temperatures are 15 -16 °C in summer and - 2 to - 3 °C in winter. Average of the very warm region is above 16 °C in summer and above 0 °C in winter. Cold and moderately warm regions have precipitation of 200–400 mm for both the summer and the winter half of the year. In the regions with low precipitation, precipitation is below 200 mm for each half of the year (Quitt 2009).

The map of potential natural vegetation assigns most of the area to oak-hornbeam woodland with Melampyrum nemorosum (*Melampyro nemorosi-Carpinetum*). Significantly less present are poplar-pedunculate oak woodland (*Querco-Populetum*), elm-pedunculate oak woodland (*Querco-Ulmetum*), oak woodland with Potentilla alba (*Potentillo albae-Quercetum*), lime-beech woodland with Tilia platyphyllos (*Tilio platyphylli-Fagetum*), oak woodland with Lathyrus versicolor and/or Buglossoides purpurocaerulea (*Lathyro versicoloris-Quercetum pubescentis, Torilido-Quercetum*) or complexes of succession stages on anthropogenic sites (Neuhäuslová et al. 2009). The narrowed area in this work includes ecozones Středohoří, Hradišťany, Žejdlík, Ohře Floodplain and Vransko defined originally within the ALRNB programme (Sádlo – Peške 1993).

In comparison to the modelled potential natural vegetation, maps of current land cover based on aerial photography show predominantly agricultural land without significant changes between 1990s, when the ALRNB project was conducted, and the present day. Non-irrigated arable land takes around 70 % of the area, followed by two categories below 10 % of land principally occupied by agriculture and mixed forests (Table 1.1).

Fig. 1.1: Study area.

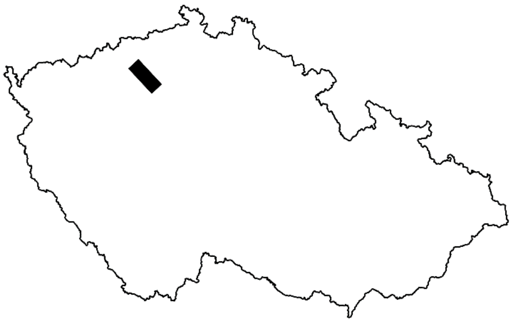

Fig. 1.2: Area elevation distribution (m.a.s.l.).

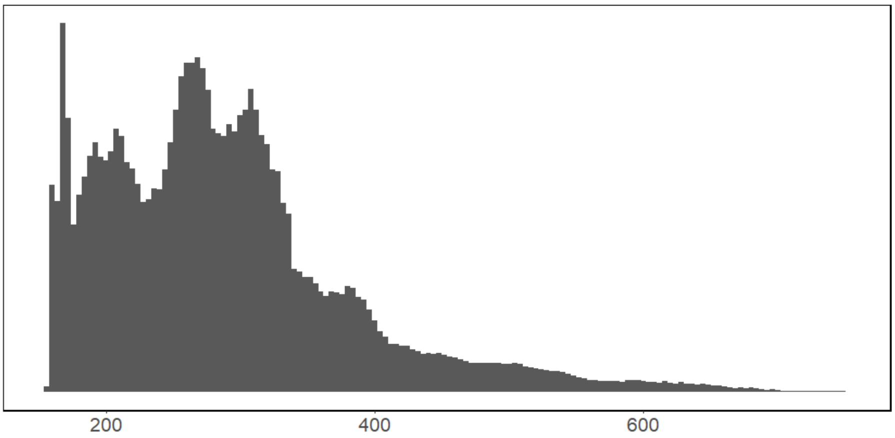

Table 1.1: Land cover for years 1990 and 2018 (Copernicus programme a, b [online]).

| **LAND COVER** | **1990 (%)** | **2018 (%)** |
|---|---|---|
| Non-irrigated arable land | 70,23 | 70,22 |
| Land principally occupied by agriculture with significant areas of natural vegetation | 7,46 | 8,24 |
| Mixed forest | 6,21 | 5,19 |
| Fruit trees and berry plantations | 3,39 | 2,58 |
| Broad-leaved forest | 3,23 | 5,16 |
| Discontinuous urban fabric | 2,78 | 2,97 |
| Coniferous forest | 1,80 | 1,41 |
| Complex cultivation patterns | 1,30 | 0,87 |
| Transitional woodland-shrub | 1,21 | 0,58 |
| Dump sites | 1,17 | 0,00 |
| Pastures | 0,70 | 2,36 |
| Industrial or commercial units | 0,13 | 0,14 |
| Vineyards | 0,10 | 0,00 |
| Green urban areas | 0,08 | 0,00 |
| Natural grasslands | 0,07 | 0,00 |
| Mineral extraction sites | 0,07 | 0,19 |
| Sport and leisure facilities | 0,05 | 0,08 |

## 2. Methodology

The literature research was focused on the surface artefact collection and methods of analysing archaeological data on a landscape scale. Publications concerning the ALRNB programme were also gathered and summarised.

ALRNB records were provided in the form of a Microsoft Access database. Location of the survey stints was recorded by corner points as millimetre distances read on a 1:10 000 map. The coordinates were transformed into S-JTSK coordinate reference system in the application UNITRANS, reviewed against georeferenced survey maps in GIS and transformed into polygons. Operations within GIS environment were executed in QGIS (version 3.4.12). AMČR components were available in geolocated form in ESRI shapefile.

Plotting and summarising components of both datasets provided an initial insight into the data. The chrono-typological dating of records was unified (Table 6.1). For spatial comparison and processing, locations of components were assigned into cells of 100 m square grid.

Temporal distribution of data was modelled using aoristic analysis and Monte Carlo simulation. Computation operations (Appendix 1) were written in R language (used version R-4.1.0) and carried out in RStudio desktop environment (Further in Chapter 7). For all values produced by pseudorandom number generators used in this work, seed was set to 1202. The plot for temporal distribution as well as plots for the other chapters were created with the use of the ggplot2 R package.

For assessment of environmental factors, values were subtracted in GIS from a terrain model and special maps. The digital terrain model and special maps were gathered from publicly available sources (more References and respective chapters). Null models of randomly assigned values were created in R. For continuity, assessment maps representing time slices with modelled aoristic weights were filtered by Gaussian filter in GIS and multiplied by raster calculator tools.

## 3. Landscape and archaeology

The main aims of the original ALRNB programme concerned the study of past landscape. The concepts which were gaining importance in 1990s are widespread in current research. The continuity of space and interconnection of geographical phenomena, resources and restraints is reflected by a shift from site-oriented approach to the focus on continuous structures (Beneš - Zvelebil 1999). No less important is the continuity in temporal dimension. Landscape is created by and creates itself a continuous chain of past interactions and behaviours, it is a product of past processes preserved to a varying degree and overlying each other (Kempf 2020). Interaction between humans, time and environment brings concepts of landscape antecedent and successor, both influenced by human actions and influencing them. Rather than by strict division between the anthropogenic and the natural factor, landscape is characterised by dynamic interaction of the two (Beneš – Zvelebil 1999).

Post-processual archaeology has brought to focus our own experience with current landscape and how it shapes our perception, and what we can understand from its past (Thomas 2012). Observation and scale are underlying in many definitions of landscape such as geographical space, which could be comprehended by human individuals or groups (paraphrased Beneš 1993). Human technical development from cartography and GIS to aviation and scape exploration have irreversibly changed the scale at which the environment could be understood and have widened the gap between present and especially past immediate experience of landscape and the accumulated knowledge concerned. Within landscape archaeology this "scientific", large-scale observation could be seen as the most common, though not exclusive approach (Thomas 2012). And although the detachment from past experience and past meanings of the landscape remains a valid reproach, large scale observation presents a useful way to study structures which might be the last remains of past events. The scale of the research also determines use of archaeological methods in landscape studies with heavy emphasis on a non-destructive approach. This work touches upon one of them - extensive surface artefact collection - but also utilises the pre-existing database of general archaeological record.

## 4 Surface artefact collection

### 4.1 Definition, objects of collection and application

Surface artefact collection also referred to as "fieldwalking" is a method of gathering archaeological data from movable objects visible on surface (see also e. g. Kuna 2004b, 305; Vencl 1968, 96). It is part of the surface survey together with the survey of anthropogenic relief features and is generally included in the group of non-destructive methods in archaeology. Although, surface artefact collection does (arguably significantly) alter archaeological record and previous collections at the same area could affect results of succeeding survey (Hlásek et al. 2018, 223; Mlejnek 2015, 19; Vencl 1968, 97).

The focus of surface artefact collection are artefacts, but the method is additionally applied to ecofacts such as daub or slag. Paramount to the interpretation of surface assemblages, however, is the distinction of collected objects by their durability. This was noted early (Vencl 1968, 96) and in Czech archaeological theory anchored by E. Neústupný (Neústupný, 2007, 59; Neústupný – Venclová 1996, 616). Neústupný defined "facts with absolute quantity" (*fakty s absolutnou četností/kvalitou*) which undergo only minimal reduction during postdepositional processes, though are still subjected to transformations. Consequently, durable artefacts are more likely to suffer from significant spatial displacement. In the case of durable HMA pottery, spatial displacement is often the result of systematic human activity, namely, transport and spread of pottery in manure. This phenomenon limits the reliability of durable pottery as an indicator of subsurface objects or residential components but might be used to research the location and extent of manured areas or even manuring strategies (e. g. Cassitti et al. 2017, Gaffney et al. 1985, Jones 2004). The limited, albeit varying, durability of prehistoric and EMA pottery makes it a better indicator of past local activities (Beneš 1998, 173; Kuna 2004b, 309; Vencl 1995, 22).

Artefacts are usually collected for further analysis, including chrono-typological classification, but with large quantities of finds, their presence might be only documented, or a sampling strategy might be applied. The key for application of surface artefact collection is the accessibility and visibility of artefacts on the surface which is commonly limited by vegetation cover, sediment, or anthropogenic structures. At a smaller scale, artefacts might be exposed on surface due to local disturbances and erosion (mole mounds, windthrows, eroded stream banks), or on a larger scale in arid and semiarid regions or by human activity. In the conditions of central Europe, surface artefact collection is most often applied at ploughed fields. Agricultural practices not only cyclically remove vegetation cover but ploughing also transports objects from subsurface situations to surface (Kuna 2004b, 306; Vencl 1995, 21).

Surface artefact collection does not remain isolated among methods of field survey. The general trend in recent decades is an integration of various non-destructive approaches and excavation. The scope of applied methods might vary depending on the aims of the research, local conditions, available resources and extent of the researched area.

### 4.2 Methods, reference units and analysis

Methods of surface artefact collection can be divided into synthetic and analytical (Kuna 2004b, 324). The main aim of the synthetic methods is to gain positive finding as effectively as possible. Usually, only areas thought to have a high chance of containing desired components are surveyed. Based on a choice of required quantity and distance from other artefacts, spatially discrete concentrations of finds are marked as “sites”. The problem of subjectivity and theoretical limits of concept of site were repeatedly brought out in the past (Kuna 2004a, 19; 2004b, 325, Shott 1995, 475). In comparison, the analytical survey holds an ambition to gain a more precise understanding of past spatial structures by covering the whole researched area evenly or gaining a representative random sample. The analytical survey commonly works with a premise that archaeological remains in space form a continuous structure of varying density. Both presence and absence of finds are recorded with the same importance. Though an absence of a component is not a proof of non-existence of activity in the past.

Synthetic and analytical methods for the most part utilize different spatial units for documentation. For the synthetic survey, reference spatial units might be points or irregular polygons representing boundaries or centres of sites. The analytical survey usually appoints regular arbitrary units which cover the whole area in a regular pattern. At landscape scale lines, arrays of parallel lines or segmented lines are usually chosen. A square grid is the most common choice for finer resolution survey.[1] Small intensively surveyed areas might be also regularly positioned within a larger regular pattern.[2] With less numerous finds, or based on the purpose of research, the precise location of all finds might be recorded with the help of a GNSS receiver.

A common approach is the creation of special maps for further analysis or visualization. Presence or quantity of finds are represented by coloured raster, graphic symbols, isolines or interpolated surfaces. Reference spatial units might be used directly for visualization and analysis, but spatial transformation becomes necessary when working with data from different survey designs (e. g. Dreslerová – Demján 2019).

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[1] The distinction between irregular polygons which are results of interpretation and regular arbitrary analytical raster corresponds with E. Neústupný’s concept of “delimiting” and “enclosing” polygons (Neústupný 1996).

[2] For instance, in the Nástup Tušimice Mines in northern Bohemia circles with 50 m diameter were positioned based on larger square 500 m grid (Smrž et al. 2011).

Additionally, the choice of larger analytical units, although with the disadvantage of generalization, might compensate for different visibility of components and produce a less disturbed pattern (Kuna 2015b). Complementary to special maps, exploratory data analysis (EDA) presents another way of initial grasping of large datasets, although most techniques used for EDA do not integrate the spatial aspect of data. EDA utilizes basic tools such as histograms, boxplots or heatmaps but also more complex approaches such as dimensionality reduction. Dimensionality reduction methods include principal component analysis (PCA), which was among other cases applied on data from the central transect of ALRNB (Kuna 1997). PCA combines dependent attributes of objects into "components" ranged by quantified ability to describe variation in data (VanPool et al. 2011, 38–41, 285–303).

Characteristic features of records of analytical surface artefact collection are high spatial and low temporal accuracy, which allows for the application of aoristic analysis – assigning "temporal weights" or modelling possible scenarios of simultaneous settlement (Dreslerová – Demján 2019).

Surface artefact collection is a common source of creation or validation of archaeological predictive models (APM). Inversely, the design of surface survey might be based on beforehand constructed predictive models (Dresler – Macháček 2008, 2013; Mlejnek 2015). APM aim to describe the probability of occurrence of components in unsurveyed areas. There are two main approaches to APM – inductive and deductive. Inductive uses attributes of already known archaeological components, deductive evaluates sustainability of landscape based on analogies and previous knowledge. Both approaches could be combined (Lieskovský et al. 2013).

### 4.3 Transformation processes and attempts to assess them

Transformation processes have for a long time been the focus of theoretical discourse in archaeology (notably Kristiansen 1985a, Schiffer 1987) and surface artefact collection is not an exception. Both natural and cultural processes were considered by S. Vencl (1995), and M. Kuna used the division into systemic (depositional, "pre-depositional"), taphonomic (postdepositional) and methodological transformations (Kuna 2004b, 310).

It is the third group according to M. Kuna's division, which includes effects of survey design, abilities of people involved in the survey, visibility of artefacts or their typological distinctiveness, that is easiest to quantify and control. It is not a straightforward process, however. There have been numerous attempts to quantify visibility of artefacts during the survey through ordinal scales including ALRNB programme itself, but the level of subjectivity and uncertainty remains. State of crops might be much easier to assess than light conditions, which can change within minutes, or weather conditions in the span between ploughing and survey (Shott 1995, 480). Further, our ability to recognize artefacts is influenced by the character of artefact and soil matrix and by contrast between the two or presence or absence of "background-noise" such as gravels or recent refuse, and even spatial distribution of artefacts, where artefacts within clusters have greater probability of discovery. This has been demonstrated by seeding experiments, where a beforehand known number of objects of different sizes, shapes and colours was dispersed and then the number of recovered items of each category or density was compared (Wansnider – Camilli 1992). Individual abilities of the people involved also factor in the number of documented objects. According to M. Kuna (2004b, 317), this is more noticeable with stone tools and can be mitigated by survey design. What we are able to document is also determined by both spatial and temporal units and the way we record observed components. Rather than to operate with the presence or absence of components some authors propose to utilize probabilistic distributions which better reflect the varying accuracy of archaeological data (Demján – Dreslerová 2016).

Even more difficult than quantifying factors of archaeological research, which mostly take part during a limited present or recent time, is assessing long-term impact of postdepositional processes. When it comes to surface artefact collection land use, erosion and accumulation, and chemical disposition of soil count for important factors. Modern ploughing techniques are responsible for the movement of artefacts in ploughsoil (Kuna 2004b 16–17). This effect is however secondary for less durable artefacts collected by extensive survey designs where reference spatial units are likely to extend the distance pottery might be moved before its destruction. Accumulation and erosion might reveal, cover, or transport artefacts (Kuna 2004b, 13–14). Various ways of assessing erosion and accumulation have been proposed within and outside publications concerning surface artefact collection including the application of Universal Soil Loss Equation (e. g. Devátý et al. 2019) or considering soil depth (Smrž et al. 2011). Preservation of artefacts is influenced by soil acidity and alkalinity (e g. Beneš 1998, 189) and there have been attempts to assess the ability of various soil types to preserve organic and inorganic materials (Kibblewhite et al. 2015). Rather than trying to evaluate postdepositional processes directly, some authors adopt a different approach, operating with attributes of artefacts themselves such as mean weight or degree of abrasion as proxies of past transformations[3] (see also Shiffer 1996, 267–279).

The trickiest (though for archaeology an object of interest in itself) are processes stemming from cultural behaviour. There have been numerous attempts to grasp aspects of living culture which determine its transition into archaeological record (Schiffer 1987, in Czech archaeology e. g. Beneš 1989), mostly in the framework of ethnographic parallels. However, part of the archaeological community remains critical to our ability to define universal rules of cultural transformations, especially without a deeper understanding of natural processes (Shahack-Gross 2017). Yet, there are some observations which should be considered. Within Czech territory, prehistoric pottery documented on surface is regarded as predominantly originating from residential components. Presence, depth and size of sunken features in habitation areas are key for our ability to document residential activity by different survey methods (Dreslerová – Demján 2019, Kuna 1998a, 197; Kuna 2015b, 169). The variability of this factor is indicated by the varying ratio in which residential or funeral components of archaeological cultures are detected by excavation (Kuna 2004b, 311–312, 2015b).

### 4.4 History of surface artefact collection in the Czech Republic and Slovakia

In the Czech Republic and Slovakia, as well as in other countries, artefacts found at the surface have been part of archaeology from the start. At first, the aim was to collect valuable or interesting items (Vencl 1995, 11), later in the 1920s and 1930s, coincidental finds and activity of non-professional archaeologists figured heavily when it came to surface finds. Locations were referred to as vaguely as by parishes, minor place-names, proximity to any significant object such as a church or a hill, or by a parcel number (e. g. Andel 1928; Gottwald 1932, 6). In the Slovak territory, one of the first notable endeavours was the survey organized by Š. Janšák in the 1930s which focused on obsidian industry and deposits. Aside from his co-workers, Janšák engaged local people who regularly encountered obsidian artefacts while working on their fields (Janšák 1935, 9–16).

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[3] To provide an example, A. Daliesová (2010, 33) utilized the fragmentation index understood as average pottery weight within a survey polygon, where larger fragments were considered as undergoing lesser displacement. Z. Smrž, M. Kuna and A. Káčerik (2011, 184, Tab. 8) combined ordinal scales of visibility at the time of survey and the degree of abrasion, and aggregated categories of soil depth into “the coefficient of reduction”.

In Bohemia and Moravia, after World War II, both professional and non-professional archaeologists took part in surface artefact collections. To name a few, J. Spáčil and P. Ondráček, who focused on stone industry, were active in Moravia (Janásek – Skutil 1954, Klíma 1953) and A. Knor published finds revealed by ploughing in NW Bohemia (Knor 1954). The rich activity of amateur archaeologists is reflected in the paper by S. Vencl (1968) – one of the first contributions concerning the methodology of surface artefact collection in Czech archaeology was largely intended for non-professionals. Vencl stressed the importance of solid documentation and precise localization (at that time reference to two stable points such as a church or a river was recommended) and named environmental conditions where archaeological surface finds could be most likely expected. Vencl discerned preliminary survey (*orientační sběr*) applied first to search for sites, methodical survey (*soustavný sběr*) conducted in lines or stints, selective survey (*výběrový sběr*) where only some typical sherds are collected, and systematic survey (*systematický sběr*), here understood as absolute collection of all artefacts. Although Vencl emphasized the importance of repeated survey in long-term research of regions, he also noted that intensive repeated surface artefact collection could be destructive.

Extensive enterprises were carried out in Slovakia after the 1950s, focusing on areas of parishes or even micro-regions. The main aim was the localization or verification of sites mostly in areas where past activities were assumed based on environmental conditions (strategic points in the landscape, locations close to water sources, river terraces), or other indications (minor, place-names, reports from local people, older publications). This way the surface artefact collection was utilized as part of the surface prospection in the 400 km$^2$ area of the Ipeľ river in 1955 (Petrovský-Šichman 1961), or prospection of sand dunes in village Bohatá (Kolník 1957). Surface artefact collection was likewise used to expand artefact assemblages from known locations. For instance, in the parish of Kechnec in eastern Slovakia, repeated surface artefact collection yielded over 4000 pieces of Paleolithic chipped stone industry (Bánesz 1959, 205). To this era dates one of the first Slovak publications summarizing archaeological fieldwork in which Š. Janšák (1955) noted the importance of surface survey in terms of both the survey of anthropogenic relief features and surface artefact collection. Janšák recommended surface survey to be applied before excavation and as an independent way of gaining knowledge of past landscape (Janšák 1955; 11, 152).

Although especially since the 1990s and with connection to the ALRNB programme Czech publications concerning surface artefact collection reflected most frequently national and English written literature (Kuna et al. 1993, Vencl 1995), significant research in neighbouring countries was also reflected upon. In 1985 J. Klápště (1985) published the reflection on the immense Polish project Archeologiczne Zdjęcie Polski – a programme which held ambition to survey all available areas in Poland and document all detected sites.[4]

Thematical, personal and spatial ties link micro-regional scale research in Northern Bohemia after the 1970s to systematic surface artefact collection in the Czech Republic and to the ALRNB programme. Coal mining spurred intensive archaeological research in the area of Lužický and Lomský stream, which included questions of continuity of settlement or relation to the natural environment (Beneš 1991a, Beneš 1991b, Smrž 1987, Smrž 1991).

Research projects utilizing surface artefact collection in the study of Early Middle Ages in Bohemia published at the turn of the 1980s and the first half of the 1990s, works of M. Gojda, E. Černá, P. Meduna, J. Frolík and J. Sigl could be mentioned. In the first, which concerned lower Vltava basin, M. Gojda (1989) noted that the oldest EMA pottery ("Prague-type pottery") was only rarely detected by surface artefact collection. Aside from the cultural reasons this was attributed to possible interchangeability with prehistoric pottery. Although the paper reflected observed preferences for certain environmental conditions, it was with acknowledgment that research of different landscape types remained uneven. The second study concerned research of Pětipsy basin in NW Bohemia which utilized surface artefact collection and survey after topsoil-stripping. The observations of E. Černá and P. Meduna agreed with M. Gojda's opinion. There was a marked difference between components identified by the two research methods, where the ratio of sites documented by fieldwalking grew steadily towards the later EMA phases. In Pětipsy basin no funeral components were recognized by either surface artefact collection or topsoil-stripping (Meduna – Černá 1991). In the third case, J. Frolík a J. Sigl (1995) in their research of EMA settlement structure of Chrudimsko tried to define the site by the quantity of finds. In this case first by criteria of 20 and later 7 sherds. Aside from the choice of site as a reference unit,

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[4] Later M. Kuna (2004b, 342–344) added a more critical view reflecting the impossibility to obtain a definitive and complete picture, as well as problems with the concept of site.

their approach could be considered as synthetic with regard to where the survey was applied - primarily, areas along watercourses had been walked.

The main studies concerning ALRNB methodology and results for the central transect were published in the 1990s and early 2000s (more in Chapter 5). ALRNB methodology was applied in the survey of Říčany micro-region and in modified form in areas of Loděnice and Bakov streams. Observations concerning settlement structure and continuity and preferred ecological factors in Říčany did not significantly differ from M. Kuna's conclusions regarding the central transect (Dreslerová 1998b). In Loděnice and Bakov streams aside from surface artefact collection results of previous excavations were used to study La Tène period. Pottery and sapropelite were collected during surface artefact collection, and slag was recorded. Spatial overlap of those categories showed different economic activities for areas around Loděnice and Bakov streams (Neustupný – Venclová 1996).

With the development of other non-destructive methods in the final decades of last century, surface survey became more often applied as a complementary method for its (though limited) ability to yield datable material. For instance, M. Gojda (1996) chose surface artefact collection to verify objects recognized by aerial survey in central Bohemia.

Three, for the Czech Republic key publications concerning the methodology of surface artefact collection, were published in 1994, 1995 and 2004. M. Kuna's thorough inlook into the topic first took the form of the 1994 monograph and later of a chapter in the synthesis on non-destructive archaeology *Nedestruktivní Archeologie. Teorie, metody a cíle* (2004). The works touched upon aims and objectives of surface artefact collection, the sources and origin of surface assemblages, movement of artefacts in ploughsoil, accessibility of surface assemblages, sampling and intensity of research, analysis and interpretation of data, but also included practical topics such as the workforce needed for different survey methods. Attention was given to archaeological transformations and key factors influencing surface assemblages such as attributes of archaeological entities, climate, accumulation and erosion, agriculture, construction and mining activities, and research itself. As for the methods of surface artefact collection, these were divided into "synthetic" (also "evaluative" or "site seeking") and "analytical". Different behaviour of prehistoric pottery with limited durability and durable artefacts such as stone industry and pottery from High Middle Ages onward was recognized. M. Kuna stressed the necessity of considering even small quantities of finds and the long-term effect of land use (including, for example, the presence or absence of sunken features within succeeding prehistoric cultures) or the difference in frequency of typologically distinctive features between chrono-typological periods. The paper published in 1995 by S. Vencl also reflected postdepositional processes divided into two main groups – processes of natural origin (erosion, bioturbation, windthrow) and cultural processes (trampling, agriculture, archaeological activity). S. Vencl emphasized the role of surface artefact collection in recording components not represented by subsurface objects and the necessity of repeated survey. The author, who focused on durable Mesolithic stone industry, found contemporary distribution maps based on surface finds inconsistent and heavily disturbed by secondary and tertiary factors.

No radical shift when it comes to surface artefact collection could be noted in Slovak archaeology from the 1950s to the 2000s. The method was applied as a tool to search for sites, verify previously known locations, or monitor them (including previously known or even partially excavated locations damaged by ploughing), or to gather more artefacts (e. g. Michalík 2009, Roth 1994, Soják 1999, Vladár 1962, Žebrák 1983). A novelty, applied not just to surface artefact collection, was the recording of positions as millimetre distances read from a map frame (e. g. Soják 1999). The technique, originally utilized by the Institute of Archaeology in Prague (Kuna 2004c, 383), was used both in Slovakia and the Czech Republic.[5] Similar to Czech territory, surface artefact collection become a possible auxiliary method for other non-destructive methods such as aerial photography or geophysical survey (Beljak Pažinová – Melo 2015, Kuzma 1996, Kuzma – Tirpák 2004). At least since the late 2000s a more precise description of the applied methodology cold be noted. Artefacts were usually collected along lines walked in even distances or location of every artefact was recorded with the help of a GNSS receiver (e. g. Bednár – Vajdíková 2006, Palinderová, 2016, 19–20).

Even after the turn of the millennium, surface artefact collection continued to be used in Paleolithic research. From more recent Slovak studies, T. Michalík's (2011) surveys of the Trenčín basin could be mentioned. In the Czech Republic, O. Mlejnek's research of *Drahanská vrchovina* is notable. Mlejnek utilized site as a reference unit, though all artefacts were also located by a GNSS receiver. However, Mlejnek understood surface artefact collection primarily as a tool to search for stratified layers,

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[5] Before the widespread use of GNSS receivers, this method helped with more precise localization, though some individual inconsistencies among archaeologists did exist. Most notably in the varying order of listed horizontal and vertical coordinates (Tencer 2008, 268).

or to study the limited range of questions such as settlement strategies, or as input data for predictive models. Predictive modelling was used in this case to plan the survey strategy (Mlejnek 2015, 17–21).

Integration of various non-destructive methods found its use in La Tène period research. Surface artefact collection, magnetometry and metal detectors were utilized at location Mšecké Žehrovice III to detect slag. Over a limited area, total collection was carried out and all pieces of slag were divided into weight classes. Large pieces of slag spatially correlated with subsurface objects later confirmed by excavation (Venclová – Křivánek 2008). Analytical surface artefact collection together with electric resistance was used to research the inner structure of the oppidum in České Lhotice. The weight and number of finds were used to calculate the "fragmentation index" (*index fragmentarizace*), which was taken into consideration in the interpretation of archaeological transformations (Danielisová 2010, 32–33; Mangel – Musil 2014). Similarly, the "fragmentation index" initially used in the work of A. Danielisová and a combination of various non-destructive methods were used to survey the quadrangular enclosure near Stožice, identified with the use of ALS and expected to be La Tène "Viereckschanze". Crop mark and electrical resistance helped to verify the shape of the ditch. Analytical surface artefact collection showed a high correlation of larger pieces of prehistoric and La Tène pottery and daub with the inner area of the enclosure. HMA and subrecent pottery which appeared more fragmentary and shoved even distribution was contributed to manuring (Hlásek et al. 2018).

Surface artefact collection also continued to be used in the Early Middle Ages research. Data from older surface artefact collections were the main source of M. Ježek's study (2007) of medieval settlement structure of the Jaroměr area. The work heavily focused on processes related to the turning point in 13th century operated with concepts of "archaeological site" (*archeologická lokalita*) or "site" (*naleziště*) based on finds quantities, which were set differently for EMA and HMA (Ježek 2007, 525). A different approach was chosen by P. Dresler and J. Macháček (2008). Analytical surface artefact collection was in this case used to verify a predictive model based on the State Heritage Monument Protection Database – *Státní archeologický seznam České republiky* (*SAS*). Research of the settlement surrounding Great Moravia centre in Pohansko showed non-random spatial distribution with connection to the centre. Based on the spatial distribution of settlement in hinterland and absence of storage pits in the 9th century, the authors interpreted the situation as a dependent centre with supporting hinterland (Dresler – Macháček 2008). In the later seasons, the research expanded in both temporal and spatial scope to the timespan of the entire EMA from 6th to 13th century in a wider region of Podijí. Surface artefact collection was utilized not just to verify the predictive model, but also to plan the field campaign. However, the predictive model for the larger region showed as less reliable. Extensive surface artefact collection was carried out over a wider area, while chosen smaller locations were surveyed intensively. Aerial survey and survey with metal detectors were also incorporated into the project. With the exception of terrain depressions, the spatial distribution of metal objects and pottery correlated with crop marks. Overall, a shift in settlement was observed. From significant occupation of local terrain elevations in the floodplain valley in the 6th century, to denser structure expanding past the floodplain border in the Great Moravian period and finally, reduction, shift to the floodplain border and appearance of new more differentiated centers in 10th century after the collapse of the Great Moravian Empire (Dresler – Macháček 2013). Analytical surface artefact collection was likewise part of survey of EMA – HMA settlement in Suchomast. The research pinpointed some of the limits of surface artefact collection in medieval archaeology. While the method helped to understand the extent of the settled area in EMA, most of the metal finds, the key for recognizing copper alloys processing at the site were discovered using metal detectors. Even more importantly, HMA pottery widely spread and dislocated in the landscape due to manuring could not be used as a sign of later settlement. Excavation was necessary to prove HMA objects and thus the continuous use of the area (Štefan et al. 2020).

In Slovakia, one of the most notable recent examples of surface artefact collection was the research of Žitava Valley at which *AÚ SAV* and Department of Archaeology of Comenius University in Bratislava cooperated with the *Romano-Germanic Commission, DAI, Frankfurt.* The most thorough research concerned the EBA settlement at Vráble-Fidvár, where a combination of aerial photography, surface artefact collection, geophysical survey, drilling, topsoil sampling and excavation was applied. The surface survey took part in years 2007, 2010 and 2014. During the first extensive survey in 2007, all material was collected. The overall weight of finds reached around 2 t. The survey in 2010 was divided into two surveys with different resolution. In the extensive survey, only the number of sherds was recorded, and they were not collected. For a finer resolution, two areas of 20 x 20 m were chosen based on finds density and dived into a 2 x 2 m grid. In those areas, all finds were collected to be chrono-typologically classified. From large-scale perspective, the surface finds pattern reflected the structure observed by the geophysical survey. Within the finer grid, surface artefact collection followed by topsoil sampling and excavation suggested only indirect relation of surface finds to houses and alleys. Rather than houses or alleys the finds from upper layers and surface correlated with surrounding cultural pits. The large-scale survey in 2014 detected concentrations of higher sherd densities interpreted as an indicator of areas of intensive activity surrounding the main settlement (Falkenstein et al. 2008, Müller-Scheeßel et al. 2016, Rassmann et al. 2018). Aside from the research of EBA sites, surface artefact collection was also part of the 2010 and 2012 surveys in Vráble – Veľké Lemehy, where Neolithic long houses were recognized (Furholt et al. 2014).

Clearly, interpretation of extensive surface artefact collections was influenced by tools available to process geolocated data. Use of GIS tools in Czech archaeology could be traced to 1990s, not excluding the ALRNB project (Kuna 1997). Aside from GIS, the intensity of research at micro-regional scale was influenced by the existence of easily accessible pre-existing databases (e.g. Balík 2003, Jechort 2003). Often data from excavations, surface collections and other non-destructive methods were combined to study past landscapes. Similarly to the 1980s landscape-oriented research in Northern Bohemia, factors like elevation, elevation over surrounding terrain, aspect, slope, distance from a water source or ore deposits and soil types were examined. Aside from environmental factors, social indicators such as the continuity of settlements or distance of open and fortified settlements might have been considered. A step further from the analysis was the construction of archaeological predictive models. In Slovakia, the widespread use of GIS tools could be noted since late the 2000s (e. g. Tencer 2008) and since the 2010s a number of studies analysing primarily the interaction between settlement and environment were published. Unlike the Czech Republic, in Slovakia, despite the existence of the CEANS database project (Bujna et al. 1993, Tencer 2008), locations were mostly extracted from published literature and excavation reports separately for every publication (e. g. Daňová – Gabulová 2014, 194; Malček et al. 2018, 30; Tóth 2010, 64).

Although some decades have passed since the beginning of the ALRNB programme, its influence could be traced even in recent publications. In 2011 Z. Smrž, M. Kuna and A. Káčerik published results of systematic surface collection from Nástup Tušimice Mines in northern Bohemia, where rescue excavation prompted by surface coal mining is planned until 2030. The methodology of the survey reflected the ALRNB programme but also aimed to correct its shortcomings (more in Chapter 5). The surveyed area was divided into a core square grid with 500 x 500 m cells (finer grids were used if higher finds density was expected or observed) and circles of 50 m diameter where survey took part were delineated based on the grid. Factors such as slope, soil depth, erosion potential, catchment area for soil accumulation, abrasion and average weight of finds, visibility at the time of the survey or the portion of more precisely dated finds were noted. A "reduction coefficient" was estimated based on surface visibility, abrasion of finds and soil depth. Comparison of the surface artefact collection and later excavated area showed small spatial correlation between recorded components. The overall results supported long-term continuity of prehistoric settlement. The authors also noted a decline in quantity and quality (greater fragmentation and smaller ratio of datable finds) of surface assemblages in comparison to the previous decades. In another case, D. Dreslerová and P. Demján (2019) used data from the central transect of the ALRNB programme among other datasets to study the development of settlement structure in central Bohemia with use of algorithmic modelling (more in Chapter 5).

## 5. ALRNB programme

ALRNB - Ancient Landscape Reconstruction in Northern Bohemia was a landscape-oriented archaeological research programme established in 1990. The initiator of the project, Marek Zvelebil from the Department of Archaeology at Sheffield, joined his efforts with Martin Kuna and Jaromír Beneš from the Institute of Archaeology in Prague. Other participants from both Great Britain and Czech Republic also took part or carried out partial analyses.[6] Data were collected predominately by surface artefact collection carried out in 1991–1995. The surveyed area consisted of two transects in northwest and central Bohemia (Beneš et al. 1992, Kuna 2004b, 344–346, Zvelebil et al. 1993, 93–94).

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[6] Dana Adelsbergerová (database and GIS support), Mark Beech (archaeozoology), Vladimír Brůna (aerial photography and GIS support), Simon Butler (palynology), Joe Claxton (database and GIS support), Dagmar Dreslerová, Patrick J. Foster, Jan Frolík (analysis of medieval pottery), Eva Hajnalová (archaeobotanical analysis), Roman Křivánek (geophysical survey and cartography), Petr Meduna (analysis of medieval pottery), Lubomír Peške, Jiří Sádlo (botany), Miloslav Slabina (analysis of prehistoric pottery), Zdeňek Smrž (analysis of prehistoric pottery), S. Vencl (analysis of prehistoric lithic artefact) (Beneš et al. 1992, 337, Zvelebil et.al 1993, 95).

## 5.1. Aims

The listed aims of the project shifted slightly between different publications, though the goals remained more general rather than narrowly defined. They could be divided into topics of settlement and landscape archaeology, implementation of paleoecological and non-destructive methods, and conversion.

Aims as presented in 1992 (Beneš et al., 337–338):
- Reconstruction of the main attributes of the landscape from the Mesolithic to present times and identification of the key trends in the long-term development
- Reconstruction of the settlement network as part of a cultural landscape in different periods and ecozones and analysis of the interaction between landscape and settlement structures
- Creating a strategy for preservation and use of historical relicts of cultural landscape in the present day

Aims and objectives as presented in 1993 (Zvelebil et al. 1993, 93):
– Application of landscape archaeology to the archaeological record in Central Europe
– Reconstruction of development of the cultural landscape
- Research of the Mesolithic/Neolithic transition in Bohemia
– Assessing the potential of landscape archaeology for reconstruction of the landscape destroyed by modem mining activity
- Introduction of new insights into settlement archaeology
- Development of field survey and other techniques for recording of spatial data
- Development of Sites and Monuments records
- Implementation of paleoecological research

## 5.2 Methodology

The main research method was surface artefact collection. Two transects ca. 50 x 10 and 60 x 10 km were chosen in northwestern and central Bohemia. The aim was to cover a wide range of habitats and landscape types. For further analysis, the transects were divided into parts based on ecological factors – ecozones, which were supposed to figure in the final analyses. Within the transects, areas with easily distinguishable borders suitable for surface survey (usually fields) were located and then all available areas were surveyed. For the ALRNB programme these units are referred to as polygons. If the overall area of available polygons was too vast to cover during one research season, part of the polygons was randomly chosen for survey. Polygons were further divided into 100 m wide traverses with south-north orientation and traverses subdivided into 100 m long stints. Most of the stints are therefore squares of 100 x 100 metres. In the early stages of the programme, however, part of the stints was smaller in size and in some of the polygons all tracks were surveyed. A small part of the stints from the earlier stages of the programme partially overlapped with areas surveyed later. The end and the beginning stints of most tracks also differed in shape and size from the 1 ha squares.

Distance of the traverses and the length of stints were measured by pacing with estimated mistake of 10%, direction was maintained using a compass. Every other traverse was walked by 4 or 5 people in 20 m distance. Finds within stints were registered separately for every track walked by one person. Over 5000 stints were surveyed in the central transect and almost 3000 in the northern transect (Beneš et al. 1992, Kuna 1998a 195–196, 200; Kuna 2001; Kuna et. al 1993, 122–124, Zvelebil et al. 1993). Test pitting for woodland areas, coring, test excavations, and remote sensing were planned as complementary methods, but were applied only at limited scale. Palynological samples were also obtained as a part of the programme and older archeozoological assemblages from the area were analysed. Although the results of bioarcheological analyses did not figure in later publications, the influence of this approach on Czech archaeology could be noted (Dreslerová – Pokorný 2004, 741). Slightly modified ALRNB methodology was later applied in Loděnice project, which studied La Tène residential and economic components in central Bohemia (Neustupný – Venclová 1996) or in the survey of Říčany region (Dreslerová 1998b).

### 5.3 Ecozones

The study area was divided into 13 ecological units – “ecozones”. Six ecozones were defined in the central (Kokořínsko, Všetatsko, Labe Floodplain, Branýsko, Vidrholec, Říansko) and seven in the northern transect (Krúšné hory, Bílina Basin, Středohoří, Hradišťany, Žejdlík, Ohře Floodplain, Vransko). The delimitation was based predominantly on vegetation as a proxy indicator for other environmental conditions. The scale of human impact was also considered (Sádlo – Peške 1993).

### 5.4 Analysis of the recent landscape development

Development of the landscape over the previous 200 years was analysed with the use of old maps and aerial photographs in three selected areas of Northwest Bohemia. Segments of 10 x 10 km were chosen near Most, Libčeves and Libochovice (Beneš et al. 1993, Fig. 1). Observed elements included settlements, forests, marginal woodlands, orchards and gardens, areas of water, wetlands and quarries. In the "Most" area, extensive landscape alternation caused by surface and coal mining influenced both settlement and water and wetland areas. The "Libčeves" and "Libochovice" segments both showed significant water/wetland decrease. In the "Libčeves" segment the settlement density remained relatively unchanged. Old woodland areas at slopes were often cleared for orchards, but new marginal woodlands appeared along the roadsides. In "Libochovice" a portion of woodland and marginal woodland areas remained more stable, despite significant settlement growth. Marginal riverside woodlands were substituted by roadsides woodland areas (Beneš et al. 1993).

### 5.5 Test pitting

Test pitting was applied in the municipality of Kozly (Louny district) in the northern transect, in polygon 050. Eight test pits, each 100 x 50 cm large, were excavated in stints 13, 14, and 15 in the area with a high amount of medieval and prehistoric pottery. The aim was to observe effects of accumulation and ploughing at the base of a slight slope, to compare surface and subsurface finds and estimate the possibility of reconstructing past levels of the surface. The number of artefacts in top 30 cm of ploughsoil was balanced, after that it gradually declined. Most of the bigger pottery fragments were observed close to the surface, chipped stone industry was more numerous in -30 to -90 cm level. The finds belonged to the Neolithic, Eneolithic, Late Bronze Age, Hallstatt, La Tène, Early Medieval and Roman Period. The Eneolithic and La Tène components were not recorded directly with surface artefact collection. The more intense surface artefact collection which followed the test pitting recorded an even lesser number of chronological components. The test pitting documented slow gradual accumulation of artefacts at the base of the slope caused mostly by prehistoric settlement and agricultural activity, though disturbing of the Iron Age and Early Medieval archaeological objects by modern ploughing also contributed to the effect. The area in Kozly showed gradual increase of surface level since the beginning of agricultural prehistory and maximum impact of ploughing at depth of 50 cm from current surface. The possibility of longer durability of pottery sherds in alkaline ploughsoil was also raised (Beneš 1998).

### 5.6 Palynology

Preliminary results from eight sites fromcentral transect and two sites from northern transect were published by S. Butler. At the time without radiocarbon dating. Five other sites had been cored in the northern transect. For the northern transect samples, at the site of Vranský potok S. Butler considered the possibility of early Holocene or Late Glacial age of the base of the sequence. Samples from Kostelec nad Ohří hinted at partial deforestation and agriculture during mid-later Holocene (*Butler 1993*).

### 5.7 Aerial photography

Aerial reconnaissance was carried out in the area partially overlapping the central transect. The survey included ca. 40% of the transect surface and identified clustered, linear and combined features. All sites containing clusters were assumed to be settlements. The combined feature in Jiřice was considered as a possible burial site, while linear features in Dřísy and Jenštejn were preliminarily classed as settlement enclosures. Ten from eleven features identified in areas which had been submitted to field-walking corresponded with expected settlement activity detected by surface artefacts, with the limitation that no further dating of the sites was carried out (Gojda 1993).

### 5.8 Geophysical survey

Magnetometry was used to survey chosen smaller parts of the studied area. In Praha-Vinoř in the central transect, at the site partially unearthed during rescue excavation, the method confirmed presence of a Neolithic circular enclosure (Křivánek – Kuna 1993). Magnetometry was also applied at two areas near Vraný in the northern transect, position “Za humny”, which yielded a high number of prehistoric pottery sherds, dated mainly to the Neolithic, Bronze Age and the Hallstatt period, or more widely to agricultural prehistory. The geophysical survey revealed irregularly distributed anomalies, interpreted as sunken prehistoric settlement features. Aside from agricultural prehistory, the findings from the position “Žižkaperk/Práče” were dated to the Early Middle Ages. The magnetometry confirmed two concentric linear features, previously recognized on aerial photographs, together with possible sunken features. The objects were interpreted as a possible early medieval hillfort (Křivánek 2012).

### 5.9 Archaeobotany and archaeozoology

The preliminary results of archaeozoological (sites Jenišův Újezd, Radovesice, Jenštejn) and archaeobotanical (Ďáblice, Roztoky) analyses were published in 1993 by M. Beech. The municipalities of former Jenišův Újezd (destroyed by coal mining) and Radovesice belong to the Bílina ecozone in the northern transect. All assemblages showed significant dominance of domestic species, with the exception of the Eneolithic material from Jenštejn, where wild animals, mostly wild boar, presented 37.2 % of the recognized species. In the same material the European pond terrapin (*Emys orbicularis*) was identified. M. Beech also noted a slight increase in the presence of pig in Jenišův Újezd material between La Tène A and La Tène B–D periods, as well as differences in species representation between huts and “buildings”, in Jenštejn late Halstatt/early La Téne period, where cattle were more numerous in the buildings. Dog and horse bones from La Téne period from Jenišův Újezd and Jenštejn showed traces of butchery marks. Archaeobotanical samples were analyzed from the base of the early Eneolithic storage pit at the site of Roztoky and early Roman oven floor in Ďáblice. The results showed dominance of *Triticum dicoccon* in Roztoky and *Hordeum distichon* in Ďáblice (*Beech 1993*).

### 5.10 Reflections

Comments on the ALRNB programme by Jan Kláptě, Evžen Neustupný, Jan Rulf, Slavomil Vencl and Jan Fridrich were published in the 1993 volume of *Památky archeologické*. Aside from general discussion about surface artefact collection or terminology, few other points were raised. Namely the issues of limited amount of concrete results, not-strictly defined aims and objectives of the programme and insufficiency of the chosen method to answer the research questions. The concept of ecozones was considered as too simplifying.

In the paper from 2011 Z. Smrž, M. Kuna, and A. Káčerik (2011, 170–171) reflected on some of the disadvantages of ALRNB methodology. The mentioned authors saw weak points in too large areas for the analytical units – stints, where small components might be crossed by only one traversing line. Another issue was aggregation of stints into polygons (caused by navigation limitations of 1990s), where stints are not statistically independent samples due to spatial autocorrelation. The third weak point was seen in the location of many polygons in archaeologically sterile areas.

### 5.11 Publications of results and reactions

Data from the central transect of the ALRNB programme were in their entirety or partially processed and interpreted in a series of papers published in 1990s and early 2000s by M. Kuna (1996, 1997, 1998a, 1998b, 2000, 2001), D. Dreslerová (1998a) and S. Vencl (1998). Repeatedly the studies also incorporated other surface artefact collections or results of excavations. More recently, the ALRNB data were analysed together with other surface artefact collections and AMČR database by D. Dreslerová and P. Demján (2019). Although above mentioned efforts necessarily spatially overlapped to a point, their study area both narrowed and extended the original boundaries of the central transect of the ALRNB programme. Comparatively, the data from the northern transect, which is the interest of this thesis, remained mostly unused. Their analysis and interpretation were carried out only for two small areas near Vraný by R. Křivánek (2012). The main objective of the last-mentioned paper was to compare surface artefact collection to geophysical survey and aerial photography.

The published interpretations based on ALRNB surface artefact collection were the results of varying approaches and objections. In the earliest study, M. Kuna (1996) used modern-day parishes as the basic analytical units. A year later, in a chapter the main aim of which was to introduce GIS tools on the example of the micro-region of Brandýsko, the same author transferred data into a 50 m cell-size grid to create a surface of interpolated and filtered values (Kuna 1997). Values of neighbouring stints within a 200 m radius were considered in the 1998 studies (Kuna 1998a, 210; 1998b, 111). D. Dreslerová and P. Demján (2019) worked with a modified 100 m cell grid created by simplifying shapes and rounding original coordinates. One of the main advantages of transforming input data into grids is the possibility to incorporate data with different reference units and spatial resolution. In 2001 M. Kuna used ALRNB data at the finest possible scale, taking traverses within 100 $m^2$ stints as spatial records of events. The mean of events within the stint was compared for different ecozones[7] (Kuna 2001).

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[7] The ecozones in this study did not entirely correspond with the original classification of the ALRNB project.

Other studies (Dreslerová 1998a; Křivánek 2012; Kuna 1998a, 1998b) worked entirely or for some part with original stints without further transformation.

Although the quantity of finds was thoroughly recorded in the ALRNB programme, in most of the above-mentioned studies only presence or absence of a component was considered (the exception being the work of R. Křivánek). This approach was partially caused by the difficulty to quantify the effect of transformation processes, where even one find can be a representative of a component (Kuna 2001, 38), but also enabled comparison of data from different sources.

One of the basic research questions that were studied was spatial correlation and continuity of settlement between individual periods. This was either considered by direct observation of the presence or absence of a component within the analytical unit or expected span of a residential area, and surrounding economic areas were considered. M. Kuna’s 1997 study worked with settlement cores (as areas of focal residential activities) and modelled surrounding economic areas. Similarly, D. Dreslerová and P. Demján (2019) considered overlapping of expected production areas and possible contemporaneity with the use of algorithmic modelling. M. Kuna observed significant spatial correlation of prehistoric settlements especially in subsequent periods with the exception of the Neolithic. For the Neolithic a distinct pattern, with settlement activities overall present at larger area, a different agriculture strategy was considered. The long-term stability was attributed to social factors with the model in which houses are moved short distances between generations and the overall distance only grows with growing timespan. The spatial shift was more significant for EMA settlements compared to prehistory (Kuna 1998a, 212; Kuna 2001, 50). D. Dreslerová and P. Demján noted settlement stability in field walking data from MBA onwards. At the landscape scale stability decreased in direction from “cores” with more favourable environmental conditions towards periphery, with likely periodic hiatus in periphery areas (Kuna 2001, 45, 50). Focal points of stability at smaller scale – “hot spots” were also described (Dreslerová – Demján 2019).

When it comes to structure, the reconstructed settlement cores appeared separated either by space or a watercourse with the tendency to cluster in a pair across a watercourse or in a larger group at a confluence (Kuna 1997). Later periods showed greater variation in clustering of sites (Dreslerová – Demján 2019). In comparison to prehistory and EMA, where concentrations of pottery could be attributed to settlement activity, the disperse pattern observed with HMA pottery was connected to manuring (Kuna 1998b, 108).

Dependence upon more favourable environmental conditions was observed. Almost all settlement activity appeared within 300 m distance from watercourses (Kuna 1997, 1996; Dreslerová – Demján 2019). Compared to ALRNB, the preference of higher-quality soils showed more prominently in the AMČR data (Dreslerová – Demján 2019). Within the area of central Bohemia changes of settlement densities did not appear to be strictly determined by expected development of past climate (Dreslerová – Demján 2019).

Aside of studying settlement structure, part of the ALRNB aims was methodological or related to study of the postdepositional process. It was noted that within the Elbe floodplain the prehistoric and EMA pottery was generally present at the remains of the river terraces. HMA finds were numerous in filled meanders, which was a likely result of their intentional filling in HMA or later (Dreslerová 1998a). For the central transect of ALRNB, a comparison of the number and weight of pottery finds, percentage of chronologically classified finds and season of survey was carried out. A higher percentage of stints with finds as well as a higher number of finds were documented in spring. On the other hand, the finds from autumn were on average bigger and more of them could be typologically dated. The difference was ascribed to different precipitation regime causing different visibility conditions, where in spring even smaller (and likely typologically less distinctive) finds were detected. Most of the stints did not show extreme deviance in number or weight. Comparison of the number of finds of each period to undated pottery implied the higher possibility of recognition for Neolithic a La Tène Period pottery, likely caused by their technological distinctness (Kuna 1998a).

Paper published in 1998 by S. Vencl (1998) focused on chipped stone industry from the central transect. From the ca. 700 finds initially recorded as CSI, upon closer examination ca. 100 were discarded as not being artefacts or belonging to younger than prehistoric eras and more than half of remaining group was atypical debitage. Only around 20 % of finds were classified at least within two large groups of the Palaeolithic and agricultural prehistory. The second group was four times more numerous and when it was possible to determine the there was more Eneolithic than Neolithic artefacts. In 1997 S. Vencl organized additional surface artefact survey at six available locations with Paleolithic finds. Of that, half proved negative, and the other half yielded only small assemblages. Overall Vencl considers ALRNB methodology as unsuitable for detecting components represented only by CSI where larger assemblages are necessary for dating and cultural classification and especially problematic for Mesolithic where microliths have minimal visibility even during more thorough specialized surface surveys.

## 6. Data

One of the aims of this work is the comparison of two datasets of archaeological record and their potential to reconstruct past settlement activities. Archaeological data obtained by the ALRNB programme and collected within the AMČR database were recorded over a different time span, for different purposes, and by different methods.

The ALRNB dataset is the result of five years of surface artefact collection carried out in the 1990s with the intent to gain data for study of past landscape (more in Chapter 5). The second dataset, representing general archaeological record, was extracted from the Czech national archaeological database Archaeological Map of the Czech Republic (*Archeologická Mapa České republiky*) – AMČR and included revisited records from the preceding database Archaeological Database of Bohemia (*Archeologická databáze Čech*). AMČR programme began in 2010s as a tool to collect, manage and present data about archaeological field work in the Czech Republic. The database is managed by Institutes of Archaeology of the Czech Academy of Sciences in Prague and Brno and collects records of past and present archaeological fieldwork events conducted by various methods and for different purposes, including academic research, rescue excavations or accidental finds. At present, aside of new entries reflecting current archaeological research, old records are still being revisited and retrospectively added (AMČR [online], Kuna 2015a). Given more than a century of archaeological research in the Czech Republic, AMČR not only reflects research bias but also its evolution trough time. The ALRNB and AMČR datasets differ in volume and spatial distribution as well (Table 6.2). It is proof of the immense effort dedicated to the ALRNB programme that the volume of records and the scope of the covered area significantly surpass the current scope of AMČR record. Although with the limitation that within the ALRNB programme only actively managed arable land could be surveyed, and a limited number of finds could be assigned to more precisely dated chrono-typological groups.

## 6.1 ALRNB

The source of the data was the surface artefact collection undertaken within the northern transect of the ALRNB programme (more in Chapter 4). The narrowed study area for this work was delimited by a rectangle of 13 by 32 km (Fig. 1.1). Following the field survey methodology, ALRNB records were created at the level of polygons and stints (definition of polygon and stint within programme Chapter 4). The original protocols of ALRNB programme and survey maps are deponed at the Institute of Archaeology of the Czech Academy of Sciences in Prague.

Record of each polygon included conditions at the time of the survey (description of plough soil cover, vegetation cover, weather, visibility). Polygons 1-110 were processed in printed form (Beneš – Křivánek, unpublished), access to the polygon level records for the rest of the polygons was limited. In conclusion, polygon level data was not included in this work. Records for stints consisted of the count of finds of every category in each line, the name of the person who conducted the survey in the line, overall sum and weight of finds for the stint, and four coordinates recorded as millimetre distances read on 1:10 000 map. Categories included either chrono-typological phases for pottery and some of the stone tools, or material. For this work, only pottery finds were considered. Stone industry, metals finds, clay, slag and glass were excluded. Coordinates of stint points were transformed into S-JTSK coordinate reference system in the application UNITRANS and reviewed against georeferenced plans of the survey drawn in the map. Polygons 15, 81–83, 131, 132, 184, 235, 246–249, 268–280 were excluded due to missing records or coordinates or location outside of the narrower study area. Overall, 260 polygons consisting of 2735 stints and covering an area around 23 km$^2$ were included.

The narrowed dataset contained 4030 records for agricultural prehistory and EMA and 7703 for later periods up to the present (Table 6.2), representing presence of chrono-typological-phases in stint. Finds were divided into 34 chrono-typological phases, 23 belonged to agricultural prehistory, 5 to EMA and 6 HMA and post-medieval categories (more on assigned categories in Table 6.2). The assigned phases had varying dating precision, ranging from more than 6000 (agricultural prehistory) to 70 years (EMA 1). 15 % was attributed to the agricultural prehistory without more precise determination, 9 % to the rest of prehistoric categories, 11 % to EMA and 65 % to HMA and later phases. In comparison, in the central transect of the ALRNB programme, 10 % of records belonged to the agricultural prehistory without more precise determination, 3 % to the rest of prehistoric categories, 4 % to EMA and 82 % to HMA and later phases (Kuna 1998a, Table 3).

Looking at the number of finds, 83 144 pottery sherds were collected within the narrowed study area. 67 % belonged to the HMA and later phases, 24 % to agricultural prehistory without more precise determination, 6 % to EMA, and 3 % to the rest of the agricultural prehistory categories (Table 6.1). In the central transect HMA and post-mediaeval finds represented 77 % of all recorded pottery, followed by 18 % of unspecified agricultural prehistory, 3 % for EMA and 2% to rest of the prehistoric finds (Kuna 1998a, Table 3). The northern transect showed higher ratio of more precisely dated prehistoric components compared to unspecified prehistory category for both the number of observations per stint and sum of finds.

Most numerous categories in the number of finds were Post-Medieval period 1, followed by unspecified agricultural prehistory and HMA. From the more precisely determined phases of agricultural prehistory, Neolithic, Late Bronze Age and Bronze Age with Hallstatt showed highest sums. The low numbers of Lengyel and Věteřov culture could be attributed to more precise determination of these categories. The Migration period was also represented by an extremely low number of finds.
Early Eneolithic, Veteřov culture and Migration period showed highest average weight of finds and HMA, Post-Medieval period and Post-Medieval period 1 the lowest. Outside of this work, average weight was appointed as an indicator of postdepositional processes for a small intensively surveyed area (Danielisová 2010, 32-33; Hlásek at al. 2018). On the landscape scale, however, the index incorporates distinctiveness of categories, where for the less distinct groups larger weight (and therefore size) is necessary for successful determination or might reflect wall thickness of ceramic vessels (Kuna 1998a, 203).

Unspecified agricultural prehistory had the highest average finds count per hectare, as well as maxim per hectare. Although in the ideal case one stints of ALRNB programme have area of 1 ha, that was not the case for the borders of polygons and stints from the earliest phases of the programme. Instead, the actual area of stints was used.
The lower density of HMA categories, also reflected in the central transect, is considered as an indication of manuring (Kuna 1998a, 207). This has to be paired with the acknowledgment that manuring is not an evenly manifested phenomenon. Different manuring strategies, including the composition of manure, prioritizing most or least

fertile fields, distance from settlement, and even population size and density and related volume of household waste play a role in the distribution of “manure” sherds (Cassitti et al. 2017, Jones 2004, Součková et al. 2013).

When the duration of chrono-typological phases was taken into consideration, most categories with very few finds and low stint count did not show change aside of lower value for Bronze Age and higher value for Veteřov category. Temporal density was very high from Early Middle Ages 4 onward. Aside of unspecified agricultural prehistory, LBA, FBA and aggregate category of Bronze and Hallstatt showed high values of finds per century.

For the prehistoric categories, the ratio of more precisely dated finds to sherds assigned to the whole period was considered. The comparison was applied to 1028 stints which included the category Agricultural prehistory in general and at least one other category. While M. Kuna (1998a, 203) considered for the central transect of ALRNB that a high percentage of more precisely dated finds in La Tène and Neolithic reflect better diagnostic attributes (for the central transect applied on broader categories), for the northern transect, less numerous, usually narrowly defined categories show a lower ratio of determined finds, compared to broadly defined categories such as Bronze Age, Bronze Age and Hallstatt period, with the exception of Proto-Eneolithic. Even considering only broader phases, La Tène and Neolithic values were not prominent for the northern transect.

In order to enable comparison with AMČR, naming of archaeological cultures and periods was unified and centroids of stints were overlayed by an arbitrary square grid with 100 m cells and assigned to squares (Fig. 6.2). Squares with duplicate records of the same category were filtered out. The number of records was reduced to 3819 for the agricultural prehistory and EMA. Fig.6.4 and 6.5 display the spatial distribution of original stints and the modified square grid. The surveyed units were not distributed evenly, with the largest concentration in the northwestern part of the study area and on the right bank of the Ohře river. Considering that surface artefact collection was applied only on arable land, areas with higher elevation, mostly covered with woodland, pastures and meadows were not sampled. The surveyed area lied almost exclusively in elevations below 400 m (Fig. 6.3)

One of the disadvantages of ALRNB design was grouping of the spatial analytical stints in so called polygons (reflected by Smrž et al. 2011, 170–171). Tobler’s first law of geography, which summarizes spatial autocorrelation states that “everything is related to everything else, but near things are more related than distant things" (Tobler 1970). Positioning samples close to each other can lead to overrepresentation of close values and duplicity in sampling. The most common statistical test of spatial autocorrelation is Moran's I, which is applied for continuous data such as elevation. For categorical and especially binary data, join count analysis is proposed. Join count analysis compares the observed and expected numbers of connected neighbours of same and different categories e. g. "black"/"black", "white"/"white", "black/white" (Getis 2010, 263). Using this method (function joincount.test in R package spdep, the setting with a queen type joins – joins with at least one shared point and nonfree sampling) on the ALRNB data transformed into squares, sampled cells did not appear more clustered than in expected random distribution (SD = 96.756, $p < 0.001$), although the effect might have been masked by survey design, where every other line is walked and cells which are spatially close are not directly joined.

Table 6.1: ALRNB finds.

| code ALRNB | category | stints | finds sum | average weight (g) | average finds/ha | max finds/ha | finds/ 100 yeas | sum/sum of agricultural prehistory (%) |
|---|---|---|---|---|---|---|---|---|
| PR.ZEM | Agricultural prehistory | 1755 | 19887 | 6,23 | 15,97 | 977,15 | 321,80 | 100,00 |
| NEOLIT | Neolithic | 151 | 283 | 7,14 | 2,24 | 13,58 | 20,21 | 20,15 |
| NE.LIN | Linear pottery culture | 80 | 132 | 6,47 | 2,10 | 16,00 | 18,86 | 10,30 |
| NE.VYP | Stroke pottery culture | 22 | 31 | 5,55 | 1,73 | 7,06 | 6,20 | 15,49 |
| NE.LEN | Lengyel culture | 1 | 1 | 9,00 | 1,25 | 1,25 | 0,25 | 0,89 |
| ENEOLI | Eneolithic | 35 | 56 | 14,27 | 1,95 | 17,51 | 2,55 | 15,85 |
| EN.CA | Proto-Eneolithic | 6 | 7 | 7,57 | 1,29 | 2,33 | 1,17 | 36,79 |
| EN.ST | Early Eneolithic | 6 | 13 | 25,69 | 4,54 | 8,75 | 2,36 | 7,94 |
| EN.SD | Middle Eneolithic | 6 | 6 | 10,33 | 2,23 | 5,51 | 1,09 | 6,84 |
| EN.ML | Late Eneolithic | 13 | 23 | 11,35 | 2,35 | 9,00 | 3,29 | 22,01 |
| BRONZ | Bronze Age | 6 | 8 | 10,25 | 4,00 | 12,02 | 0,52 | 40,19 |
| BR.UNE | Únětice culture | 20 | 27 | 10,70 | 1,66 | 4,00 | 4,15 | 16,33 |
| BR.S-S | Early-Middle Bronze Age | 7 | 11 | 11,91 | 1,86 | 4,17 | 1,05 | 9,70 |
| BR.SD | Middle Bronze Age | 6 | 13 | 6,23 | 2,66 | 5,73 | 2,89 | 4,56 |
| BR.VET | Věteřov culture | 3 | 4 | 19,00 | 1,34 | 2,00 | 4,00 | 8,36 |
| BR.ML | Late Bronze Age | 169 | 527 | 12,60 | 4,76 | 79,99 | 210,80 | 17,83 |
| BR-HA | Bronze Age - Hallstatt period | 235 | 772 | 11,06 | 3,90 | 45,87 | 42,42 | 28,70 |
| BR.PO | Final Bronze Age | 95 | 181 | 10,44 | 2,62 | 24,70 | 72,40 | 15,28 |
| HA.BYL | Bylany culture | 6 | 7 | 6,71 | 2,20 | 4,00 | 2,59 | 13,85 |
| HA.DLA | Hallstatt - La Tène A | 31 | 67 | 10,40 | 2,94 | 20,00 | 26,27 | 27,68 |
| LATEN | La Tène period | 78 | 146 | 9,14 | 2,28 | 9,68 | 34,76 | 19,99 |
| RIM | Roman period | 50 | 164 | 11,01 | 3,89 | 22,05 | 38,14 | 20,39 |
| SNAROD | Migration period | 2 | 2 | 15,50 | 0,95 | 1,05 | 1,00 | 3,33 |
| RS | Early Middle Ages | 363 | 1079 | 5,41 | 3,90 | 143,78 | 174,03 | |
| RS.1 | Early Middle Ages 1 | 8 | 17 | 8,88 | 2,14 | 8,07 | 24,29 | |
| RS.2 | Early Middle Ages 2 | 20 | 44 | 7,55 | 3,56 | 30,95 | 29,33 | |
| RS.3 | Early Middle Ages 3 | 130 | 163 | 6,55 | 2,17 | 8,29 | 108,67 | |
| RS.4 | Early Middle Ages 4 | 726 | 3845 | 5,76 | 11,58 | 183,97 | 1538,00 | |
| VS | High Middle Ages | 1627 | 15900 | 3,92 | 10,73 | 102,30 | 5300,00 | |
| VS.1 | High Middle Ages 1 | 709 | 2185 | 5,29 | 5,30 | 131,98 | 2185,00 | |
| VS.2 | High Middle Ages 2 | 1334 | 9505 | 4,22 | 13,59 | 643,89 | 4752,50 | |
| NO | Post-Medieval period | 23 | 91 | 3,40 | 4,48 | 18,74 | 18,20 | |
| NO.1 | Post-Medieval period 1 | 2313 | 22067 | 3,30 | 12,12 | 171,97 | 14711,33 | |
| NO.2 | Post-Medieval period 2 | 1697 | 5880 | 5,68 | 4,25 | 47,62 | 1680,00 | |

Table 6.2: Chrono-typological phases of ALRNB and AMČR.

| code | code ALRNB | code AMČR | category | from | | to | | length | count ALRNB | count ALRNB grid | count AMČR | count AMČR grid | count all grid |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ne.lin | NE.LIN | ne.lin | Linear pottery culture | 5600 | BC | 4900 | BC | 700 | 80 | 80 | 48 | 33 | 113 |
| neolit | NEOLIT | neolit | Neolithic | 5600 | BC | 4200 | BC | 1400 | 151 | 149 | 25 | 20 | 169 |
| pr.zem | PR.ZEM | pr.zem | Agricultural prehistory | 5600 | BC | 580 | AD | 6180 | 1755 | 1638 | 48 | 40 | 1676 |
| ne-en | | ne-en | Neolithic - Eneolithic | 5600 | BC | 2300 | BC | 3300 | 0 | 0 | 1 | 1 | 1 |
| ne.vyp | NE.VYP | ne.vyp | Stroke pottery culture | 4900 | BC | 4400 | BC | 500 | 22 | 22 | 33 | 26 | 48 |
| ne.len | NE.LEN | | Lengyel culture | 4600 | BC | 4200 | BC | 400 | 1 | 1 | 0 | 0 | 1 |
| eneoli | ENEOLI | eneoli | Eneolithic | 4500 | BC | 2300 | BC | 2200 | 35 | 35 | 12 | 10 | 45 |
| en.ca | EN.CA | | Proto-Eneolithic | 4500 | BC | 3900 | BC | 600 | 6 | 6 | 0 | 0 | 6 |
| en.jor | | en.jor | Jordanów culture | 4200 | BC | 3800 | BC | 400 | 0 | 0 | 2 | 2 | 2 |
| en.sch | | en.sch | Schussenried culture | 4200 | BC | 3800 | BC | 400 | 0 | 0 | 2 | 1 | 1 |
| en.mic | | en.mic | Michelsberg culture | 4200 | BC | 3800 | BC | 400 | 0 | 0 | 1 | 1 | 1 |
| en.nal | | en.nal | Funnelbeaker culture | 3900 | BC | 3300 | BC | 600 | 0 | 0 | 15 | 15 | 15 |
| en.st | EN.ST | en.st | Early Eneolithic | 3900 | BC | 3350 | BC | 550 | 6 | 6 | 3 | 3 | 9 |
| en.sd | EN.SD | | Middle Eneolithic | 3350 | BC | 2800 | BC | 550 | 6 | 6 | 0 | 0 | 6 |
| en.riv | | en.riv | Řivnáč culture | 3100 | BC | 2800 | BC | 300 | 0 | 0 | 7 | 5 | 5 |
| en.kul | | en.kul | Globular Amphora culture | 3100 | BC | 2800 | BC | 300 | 0 | 0 | 6 | 5 | 5 |
| en.snu | | en.snu | Corded Ware culture | 2900 | BC | 2500 | BC | 400 | 0 | 0 | 13 | 13 | 13 |
| en.ml | EN.ML | en.mlp | Late Eneolithic | 2900 | BC | 2200 | BC | 700 | 13 | 13 | 1 | 1 | 14 |
| en.zvo | | en.zvo | Bell Beaker culture | 2500 | BC | 2200 | BC | 300 | 0 | 0 | 3 | 3 | 3 |
| br.une | BR.UNE | br.une | Únětice culture | 2300 | BC | 1650 | BC | 650 | 20 | 20 | 25 | 22 | 42 |
| en.pun | | en.pun | Proto-Únětice culture | 2300 | BC | 2000 | BC | 300 | 0 | 0 | 2 | 2 | 2 |
| br-ha | BR-HA | br-ha | Bronze Age - Hallstatt period | 2300 | BC | 480 | BC | 1820 | 235 | 231 | 2 | 2 | 233 |
| bronz | BRONZ | bronz | Bronze Age | 2300 | BC | 750 | BC | 1550 | 6 | 6 | 25 | 20 | 26 |
| br.st.sd | BR.S-S | | Early-Middle Bronze Age | 2300 | BC | 1250 | BC | 1050 | 7 | 7 | 0 | 0 | 7 |
| br.sd | BR.SD | br.sd | Middle Bronze Age | 1700 | BC | 1250 | BC | 450 | 6 | 6 | 15 | 13 | 19 |
| br.vet | BR.VET | | Věteřov culture | 1700 | BC | 1600 | BC | 100 | 3 | 3 | 0 | 0 | 3 |
| br.luz | | br.luz | Lusatian culture | 1300 | BC | 1025 | BC | 275 | 0 | 0 | 3 | 3 | 3 |
| ppole | | ppole | Urnfield period | 1300 | BC | 800 | BC | 500 | 0 | 0 | 6 | 4 | 4 |
| br.ml | BR.ML | br.ml | Late Bronze Age | 1250 | BC | 1000 | BC | 250 | 169 | 166 | 8 | 6 | 171 |
| br.kno | | br.kno | Knovíz culture | 1250 | BC | 950 | BC | 300 | 0 | 0 | 86 | 64 | 64 |
| br.sti | | br.sti | Štítary culture | 1025 | BC | 750 | BC | 275 | 0 | 0 | 22 | 21 | 21 |
| br.po | BR.PO | br.po | Final Bronze Age | 1000 | BC | 750 | BC | 250 | 95 | 95 | 2 | 1 | 96 |
| br.bil | | br.bil | Billendorf culture | 950 | BC | 450 | BC | 500 | 0 | 0 | 1 | 1 | 1 |
| ha.byl | HA.BYL | ha.byl | Bylany culture | 800 | BC | 530 | BC | 270 | 6 | 6 | 3 | 3 | 9 |
| halsta | | halsta | Hallstatt period | 800 | BC | 370 | BC | 430 | 0 | 0 | 25 | 22 | 22 |
| ha.bil | | ha.bil | Billendorf culture HaC | 800 | BC | 625 | BC | 175 | 0 | 0 | 1 | 1 | 1 |
| ha-la | | ha-la | Hallstatt - La Tène period | 800 | BC | 30 | BC | 770 | 0 | 0 | 2 | 2 | 2 |
| ha.dla | HA.DLA | ha.dla | Hallstatt - La Tène A | 625 | BC | 370 | BC | 255 | 31 | 30 | 7 | 6 | 36 |
| ha.ml | | ha.ml | Late Hallstatt period | 540 | BC | 460 | BC | 80 | 0 | 0 | 16 | 15 | 15 |
| la.cas | | la.cas | La Téne period A | 480 | BC | 380 | BC | 100 | 0 | 0 | 4 | 4 | 4 |
| laten | LATEN | laten | La Tène period | 450 | BC | 30 | BC | 420 | 78 | 78 | 34 | 30 | 108 |
| la-ri | | la-ri | La Tène - Roman period | 450 | BC | 400 | AD | 850 | 0 | 0 | 2 | 2 | 2 |
| la.sd | | la.sd | MiddleLa Tène period | 370 | BC | 170 | BC | 200 | 0 | 0 | 5 | 4 | 4 |
| la.m-p | | la.m-p | Late - Final La Tène period | 170 | BC | 30 | BC | 140 | 0 | 0 | 2 | 2 | 2 |
| rim | RIM | rim | Roman period | 30 | BC | 400 | AD | 430 | 50 | 49 | 35 | 34 | 83 |
| ri.st | | ri.st | Early Roman period | 30 | BC | 180 | AD | 210 | 0 | 0 | 6 | 5 | 5 |
| ri.ml | | ri.ml | Late Roman period | 180 | AD | 400 | AD | 220 | 0 | 0 | 1 | 1 | 1 |
| snarod | SNAROD | snarod | Migration period | 380 | AD | 580 | AD | 200 | 2 | 2 | 5 | 5 | 7 |
| sn.ml | | sn.ml | Late Migration period | 480 | AD | 580 | AD | 100 | 0 | 0 | 1 | 1 | 1 |
| rs | RS | rstred | Early Middle Ages | 580 | AD | 1200 | AD | 620 | 363 | 350 | 25 | 23 | 372 |
| rs.1 | RS.1 | | Early Middle Ages 1 | 580 | AD | 650 | AD | 70 | 8 | 8 | 0 | 0 | 8 |
| rs.2 | RS.2 | rs.2 | Early Middle Ages 2 | 650 | AD | 800 | AD | 150 | 20 | 20 | 2 | 2 | 22 |
| rs.2.4 | | rs.2-4 | Early Middle Ages 2-4 | 650 | AD | 1200 | AD | 550 | 0 | 0 | 57 | 48 | 48 |
| rs.3 | RS.3 | rs.3 | Early Middle Ages 3 | 800 | AD | 950 | AD | 150 | 130 | 127 | 10 | 8 | 135 |
| rs.4 | RS.4 | rs.4 | Early Middle Ages 4 | 950 | AD | 1200 | AD | 250 | 726 | 659 | 30 | 28 | 686 |
| | | | | | | | | | 4030 | 3819 | 690 | 584 | 4398 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| vs | VS | | High Middle Ages | 1200 | AD | 1500 | AD | 300 | 1627 | 1561 |
| vs.1 | VS.1 | | High Middle Ages 1 | 1200 | AD | 1300 | AD | 100 | 709 | 675 |
| vs.2 | VS.2 | | High Middle Ages 2 | 1300 | AD | 1500 | AD | 200 | 1334 | 1222 |
| no | NO | | Post-Medieval period | 1500 | AD | 2000 | AD | 500 | 23 | 23 |
| no.1 | NO.1 | | Post-Medieval period 1 | 1500 | AD | 1650 | AD | 150 | 2313 | 2148 |
| no.2 | NO.2 | | Post-Medieval period 2 | 1650 | AD | 2000 | AD | 350 | 1697 | 1613 |
| | | | | | | | | | 7703 | 7242 |

Fig. 6.1: Length of chrono-typological phases.

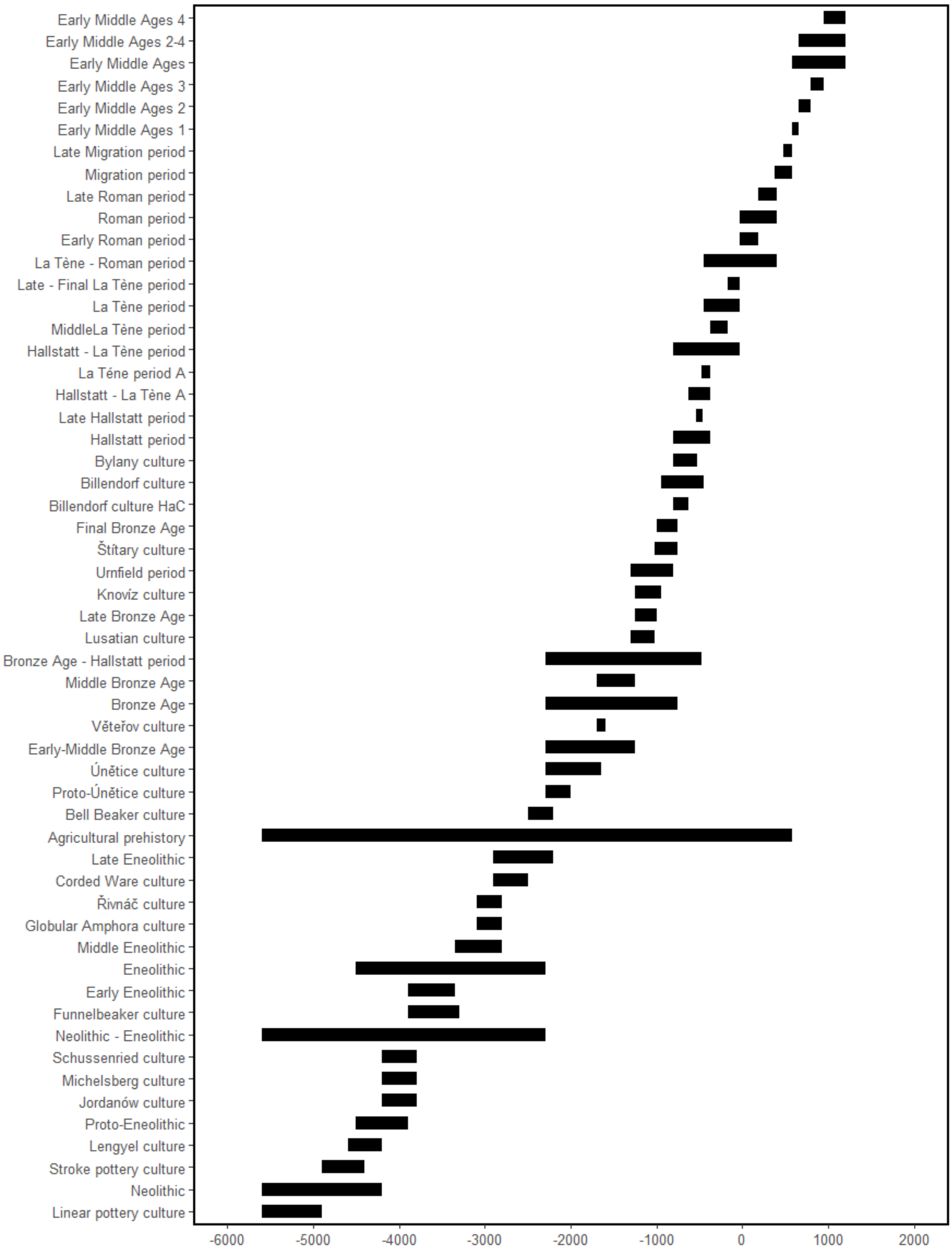


Fig. 6.2: Conversion of AMČR and ALRNB records into integrated grid. Stints of ALRNB with centroids are shown in grey fill, black triangles represent AMČR records. Derived analytical squares with evidence are projected with black outline.  Basemap ZM 10 (ČÚZK b [online]).

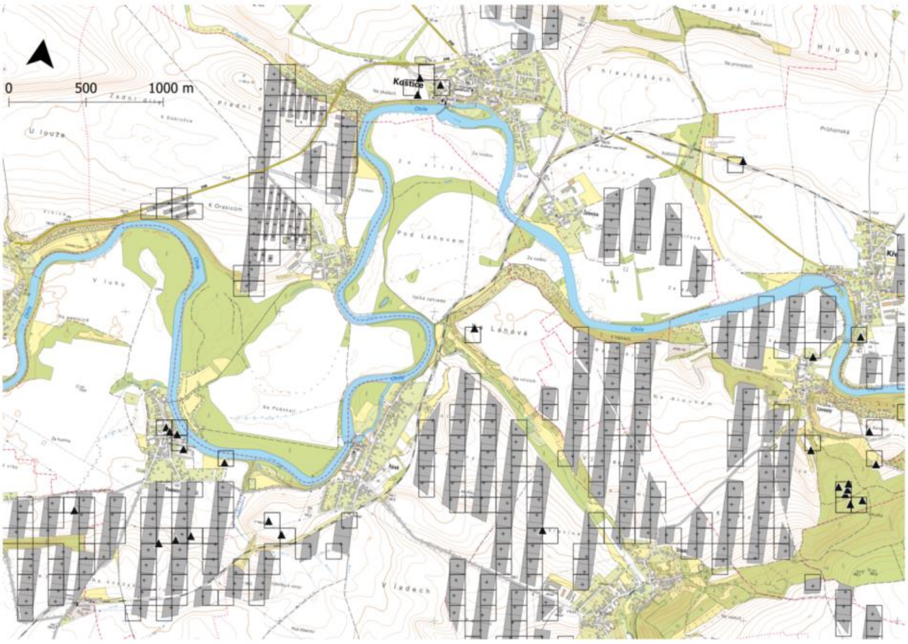


Fig. 6.3: Squares with detected evidence by elevation.

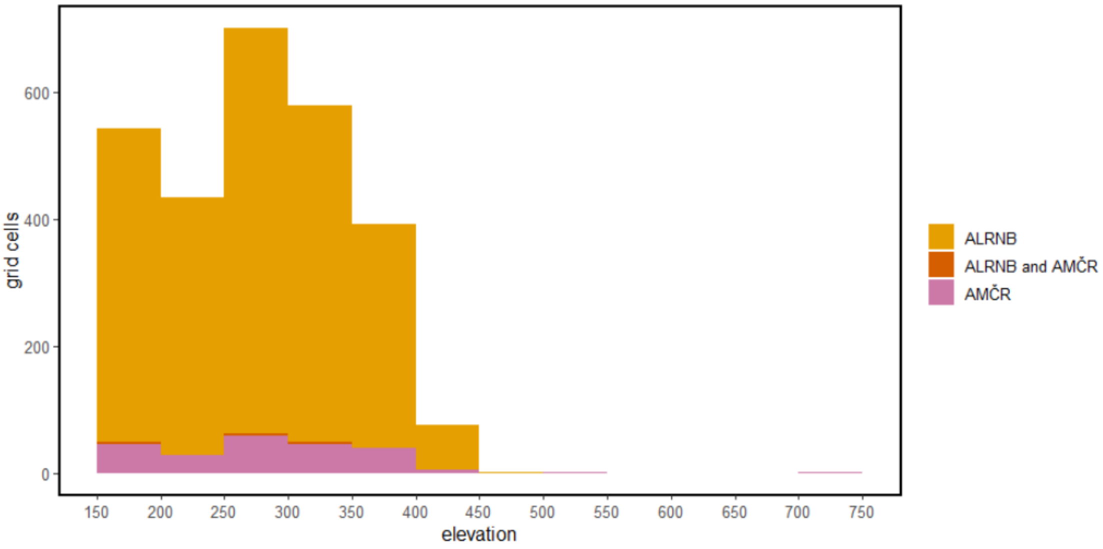


Fig. 6.4: ALRNB polygons. Basemap DMR 5G (ČÚZK a [online]).

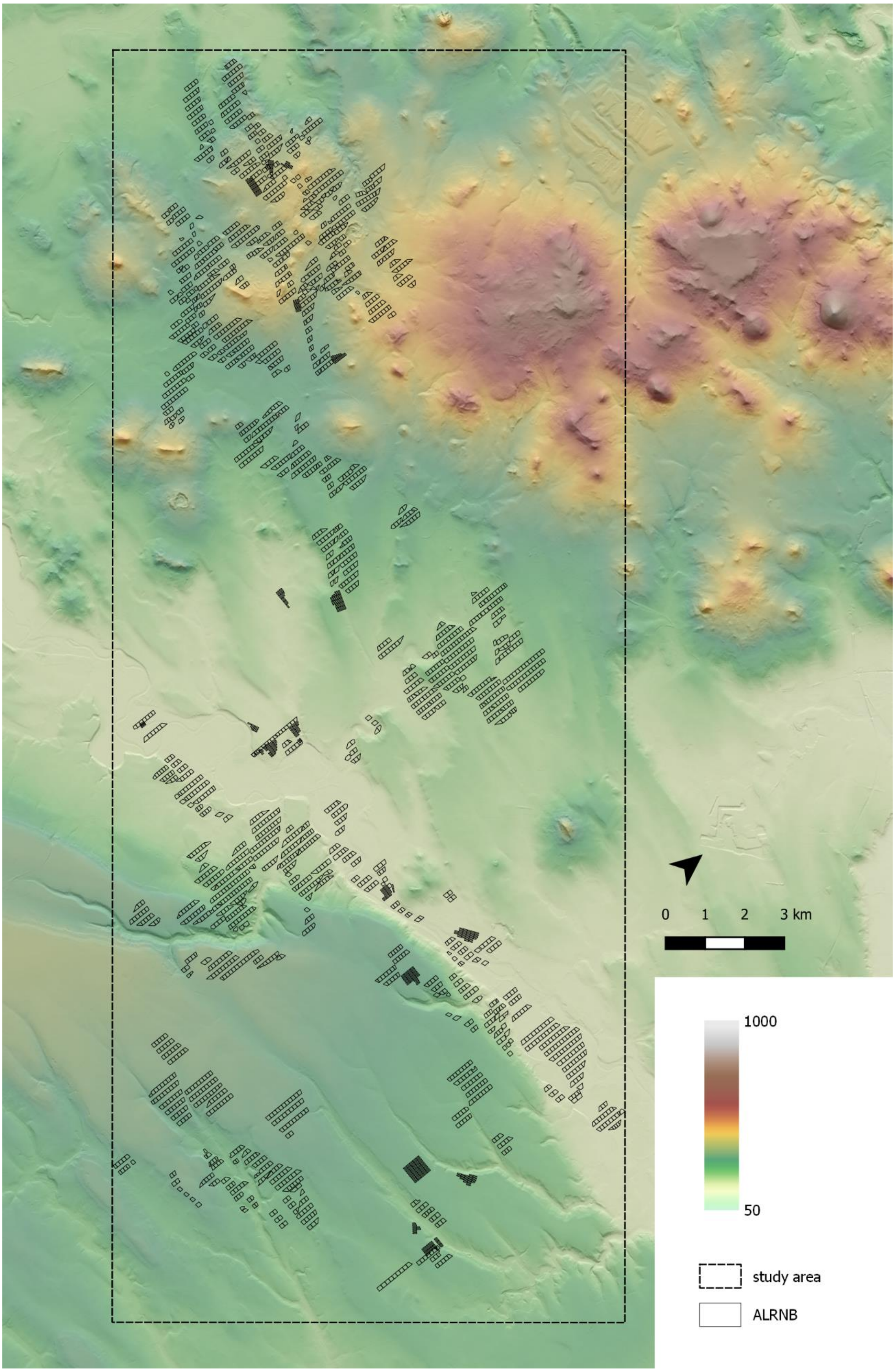
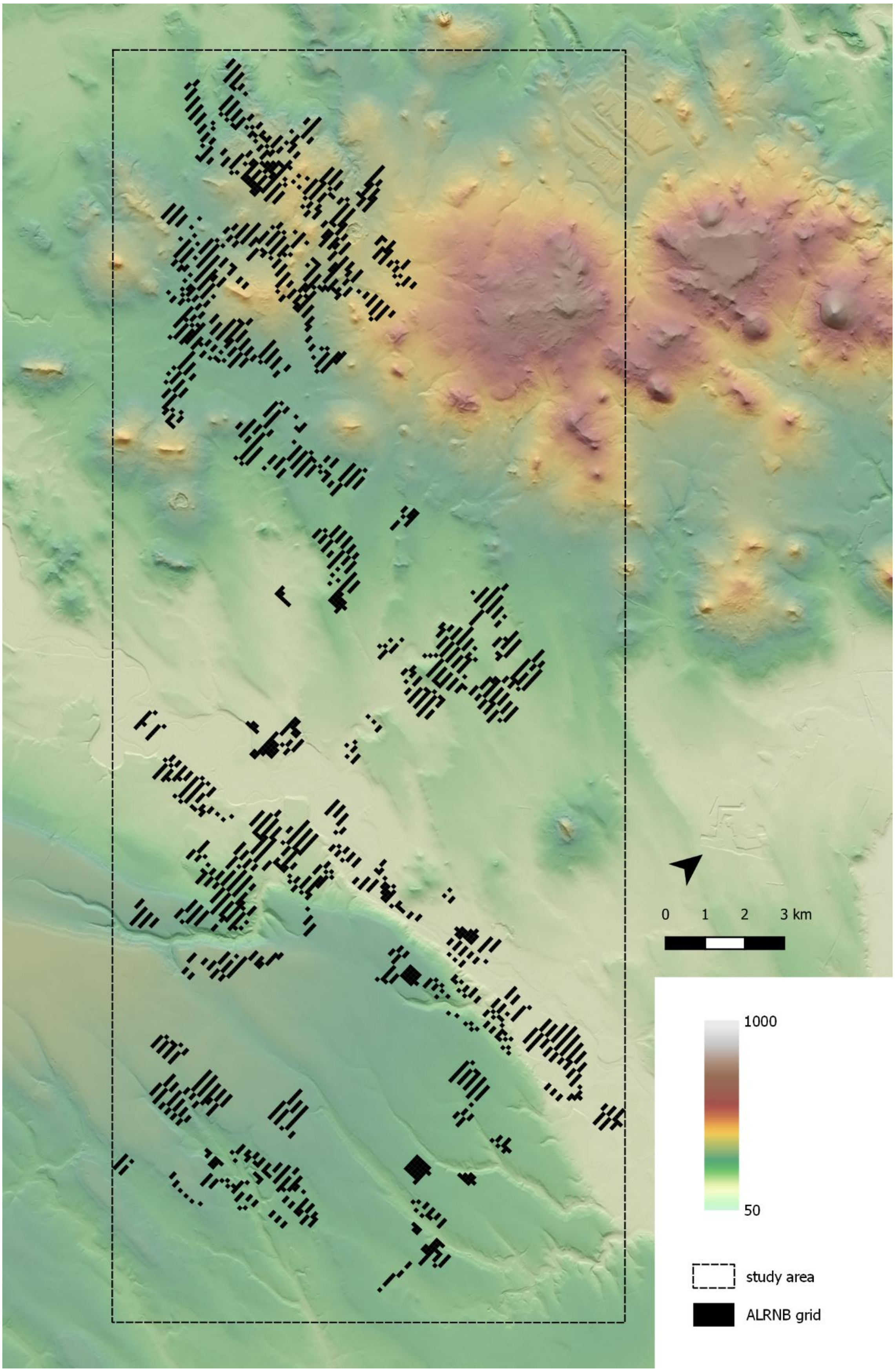


Fig 6.5: ALRNB records converted into grid. Basemap DMR 5G (ČÚZK a [online]).



## 6.2 AMČR

The dataset extracted from the Archaeological Map of the Czech Republic (*Archeologická Mapa České republiky*) valid to 29th August 2019 included a database of components located by point coordinates. Components within AMČR and this work are understood as remains of spatially, temporally, and functionally distinct past activities (more Kuna 2004a, 18). The initial dataset restricted by the study area and temporal boundary of Neolithic and EMA counted 1163 records.

Attributes utilised from the dataset included identifiers, chrono-typological classification, type of activity area, fieldwork type and accuracy of localization. Records were merged into broader categories by activity and type of fieldwork: funerary (funerary area – *pohřební areál*, funerary area unspecified – *pohřební areál nespecifikovaný*); residential (settlement – *sídliště*, lower nobility settlement – *sídlo nižší elity*, settlement unspecified – *sídliště nespecifikované*, hilltop settlement – *výšinné sídliště*, hillfort – *hradiště,* fortified central settlement – *opevněné centrální sídliště*); other activities (unspecified area – *neurčený areál*, supracommunity area unspecified – *nadkomunitní areál nesecifikovaný*, find in a secondary position –*nález v druhotné poloze,* hoard – *depot*, isolated burial – *izolovaný pohřeb*, area of non-agricultural production – *areál nezemědělské výroby*), excavation (vertical sections, large-scale excavation, trenches, trial trenches), surface finds (surface artefact collection, surface finds), non-destructive methods aside of surface artefact collection (visual and geodetic survey, metal detector survey, above-ground relics, geophysical survey), other types of fieldwork (preliminary observations, accidental finds, undocumented, other evidence).

In order to unify AMČR and ALRNB spatial resolution, records from the initial AMČR dataset were filtered by spatial accuracy. Only two highest classes of spatial accuracy (1 and 2) with expected accuracy above 100 m were included. The filtered dataset contained 690 records. It should be noted that this process did not affect the dataset evenly. The ratio of more precisely located archaeological components generally grew over more recent decades (Fig. 6.6 a). The distribution of recorded components and type of fieldwork also changed through time (Fig. 6.6b, 6.6c). The growing presence of residential components within the European archaeological record of the 20th century is a repeating pattern (Kristiansen 1985b). What is unsurprising is the accession of non-destructive methods outside of surface artefact collection since 1960's and especially 1970's, while surface collection recorded in the available dataset showed a decline after 1970's. The unspecified "other" categories within activities and fieldwork including unspecified records and less numerous categories also descended through time. Concurrence of these trends means that the distribution of components in the filtered dataset is slightly altered, with the declining presence of funerary components und unspecified categories, although the difference is not vast. Yet it demonstrates some advantages and the effect of choosing larger spatial units, which also help to compensate different visibility of components (Kuna 2015b). Parish, which corresponds with the least accurate spatial class of AMČR, was repeatedly utilized within Czech archaeology (e. g. Dreslerová – Demján 2015, Kolář et al. 2018, Kuna 1996), however the spatial resolution would not be optimal for the scope of the study area. Another approach to varying spatial accuracy is the appointment of probabilistic density (Demján – Dreslerová 2016, Dreslerová – Demján 2015), but due to the prominence of spatially more accurate ALRNB data, the method was not chosen.

What is visible in both filtered and unfiltered dataset is the minimal detection of funerary components by surface artefact collection. This supports the general opinion that surface artefact collection records predominantly residential activities (Kuna 2004b, 318–319). Due to the small overall size of the filtered dataset all fieldwork types and activity areas were kept for further analysis.

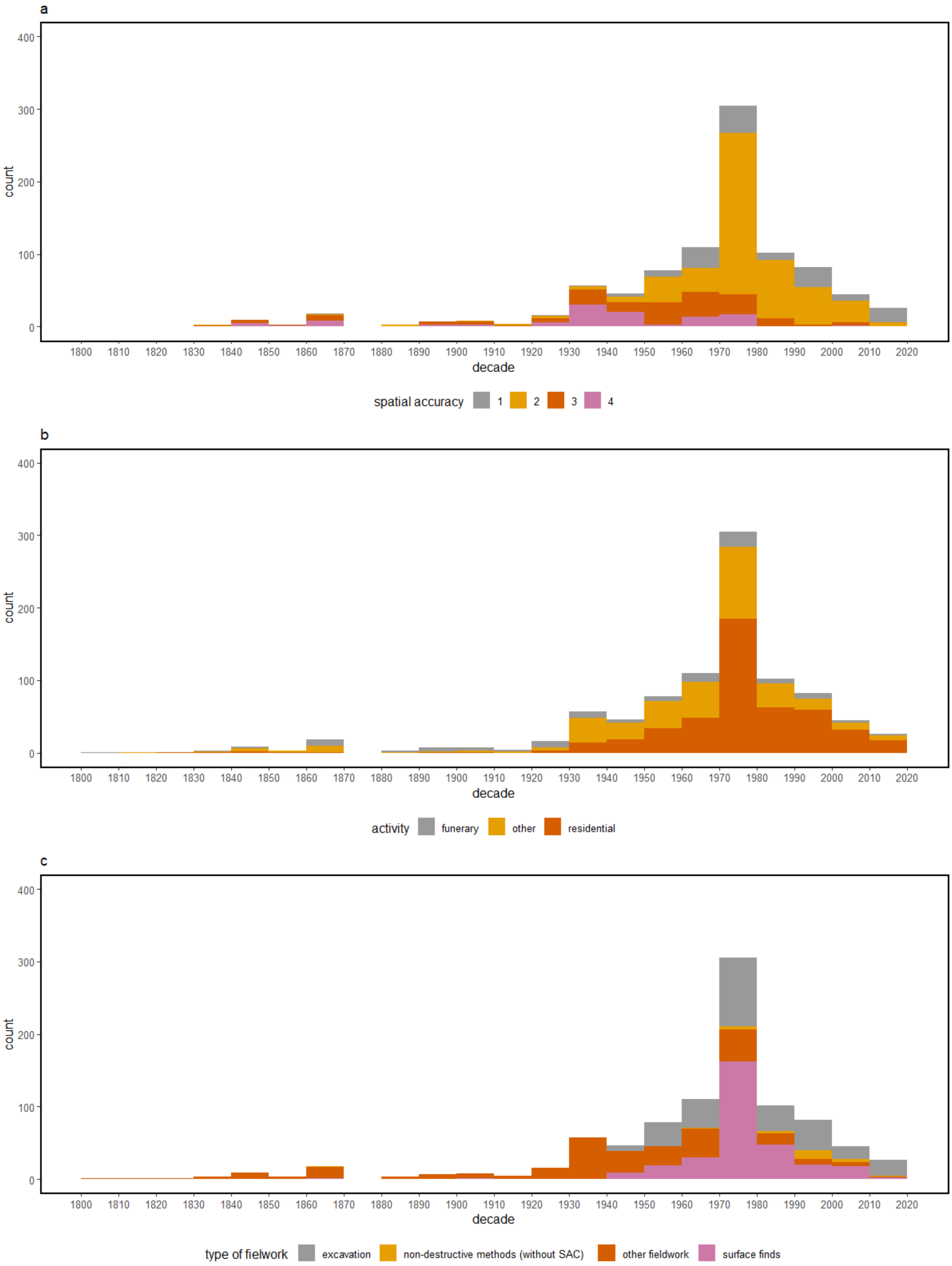
AMČR records from the filtered dataset were assigned 44 phases for agricultural prehistory and 5 for EMA (Table 6.2, Fig. 6.1), lasting from 80 (Late Hallstatt period) to more than 6000 years (agricultural prehistory). Counting the records, 7 % belonged to unspecified agricultural prehistory, 75 % to other prehistoric categories, and 18 % to EMA. In comparison to the ALRNB record (where without HMA and more recent periods 44 % of records belonged into the unspecified agricultural prehistory, 25 % to the rest of the prehistory and 31 % to EMA), as would be expected the AMČR dataset displayed notably more precise dating of prehistoric components. The most numerous prehistoric categories aside of unspecified agricultural prehistory were the Knovíz culture, the Linear pottery culture and the Roman period. There were no significant differences in the system of chrono-typological phases for AMČR and ALRNB datasets. Unification of naming of archaeological cultures and periods with ALRNB data is shown in Table 6.2.

Looking at the current land use at the location of the recorded component, even for AMČR the majority (around 60 %) is assigned to arable land, to a lesser degree to other agricultural use, with only around 9 % connected to urban areas (Table 6.4). Even considering change of land use between the time of the archaeological action and present, the real presentation of records from urbanised areas is more likely lower than higher due to urban growth.

Spatial distribution of available AMČR records was not even (Fig. 6.7, Fig. 6.8). Similarly to the distribution of ALRNB stints, more records were located in north western part and in the area surrounding the Ohře river. Absence of archaeological records from areas with higher elevation (Table 6.3) is noticeable, with noteworthy exception of the LBA site Hradišťany. The Knovíz culture hillfort (more Smrž 2011 with literature) is located on the second highest hill of České středohoří mountain range, in the location with the highest elevation of the whole study area.

For spatial consistency and to compensate uneven distribution of the research, AMČR records were projected below the same arbitrary square grid with 100 m cell as ALRNB records and assigned to squares (Fig. 6.2). Squares with duplicate records of the same category were filtered out. The final transformed dataset contained 584 records (Table 6.2).

Fig. 6.6: Distribution of components by spatial accuracy, activities, and type of fieldwork in the initial AMČR dataset.[8]



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[8] Includes 1077 of 1163 records with known time. Primarily the year of the beginning was included, if unavailable, the end year was used, 86 records were not included due to missing information.

Table 6.3

a: AMČR activity and fieldwork type. All classes of spatial accuracy.

| **count** / % | **non-destructive methods (without SAC)** | **excavation** | **surface finds** | **other fieldwork** | **sum** |
|---|---|---|---|---|---|
| **funerary** | **6** / 0.52 | **37** / 3.18 | **3** / 0.26 | **117** / 10.06 | **163** / 14.02 |
| **residential** | **24** / 2.06 | **193** / 16.60 | **175** / 15.05 | **175** / 15.05 | **567** / 48.75 |
| **other** | **6** / 0.52 | **61** / 5.25 | **141** / 12.12 | **225** / 19.35 | **433** / 37.23 |
| **sum** | **36** / 3.10 | **291** / 25.02 | **319** / 27.43 | **517** / 44.45 | **1163** / 100 |

b: AMČR activity and fieldwork type. Highest classes of spatial accuracy 1 and 2

| **count** / % | **non-destructive methods (without SAC)** | **excavation** | **surface finds** | **other fieldwork** | **sum** |
|---|---|---|---|---|---|
| **funerary** | **5** / 0.72 | **24** / 3.48 | **2** / 0.29 | **33** / 4.78 | **64** / 9.28 |
| **residential** | **22** / 3.19 | **174** / 25.22 | **149** / 21.59 | **74** / 10.72 | **419** / 60.72 |
| **other** | **6** / 0.87 | **54** / 7.83 | **105** / 15.22 | **42** / 6.09 | **207** / 30.00 |
| **sum** | **33** / 4.78 | **252** / 36.52 | **256** / 37.10 | **149** / 21.59 | **690** / 100 |

Table 6.4: AMČR records by current land use in location (Copernicus programme a, b [online]).

| **land use** | **(%)** |
|---|---|
| Non-irrigated arable land | 59,71 |
| Land principally occupied by agriculture with significant areas of natural vegetation | 9,42 |
| Discontinuous urban fabric | 9,28 |
| Pastures | 8,55 |
| Broad-leaved forest | 3,77 |
| Transitional woodland-shrub | 3,04 |
| Mixed forest | 2,32 |
| Mineral extraction sites | 1,30 |
| Industrial or commercial units | 1,01 |
| Complex cultivation patterns | 0,58 |
| Fruit trees and berry plantations | 0,58 |
| Sport and leisure facilities | 0,43 |

Fig. 6.7: AMČR records. Basemap DMR 5G (ČÚZK a [online]).

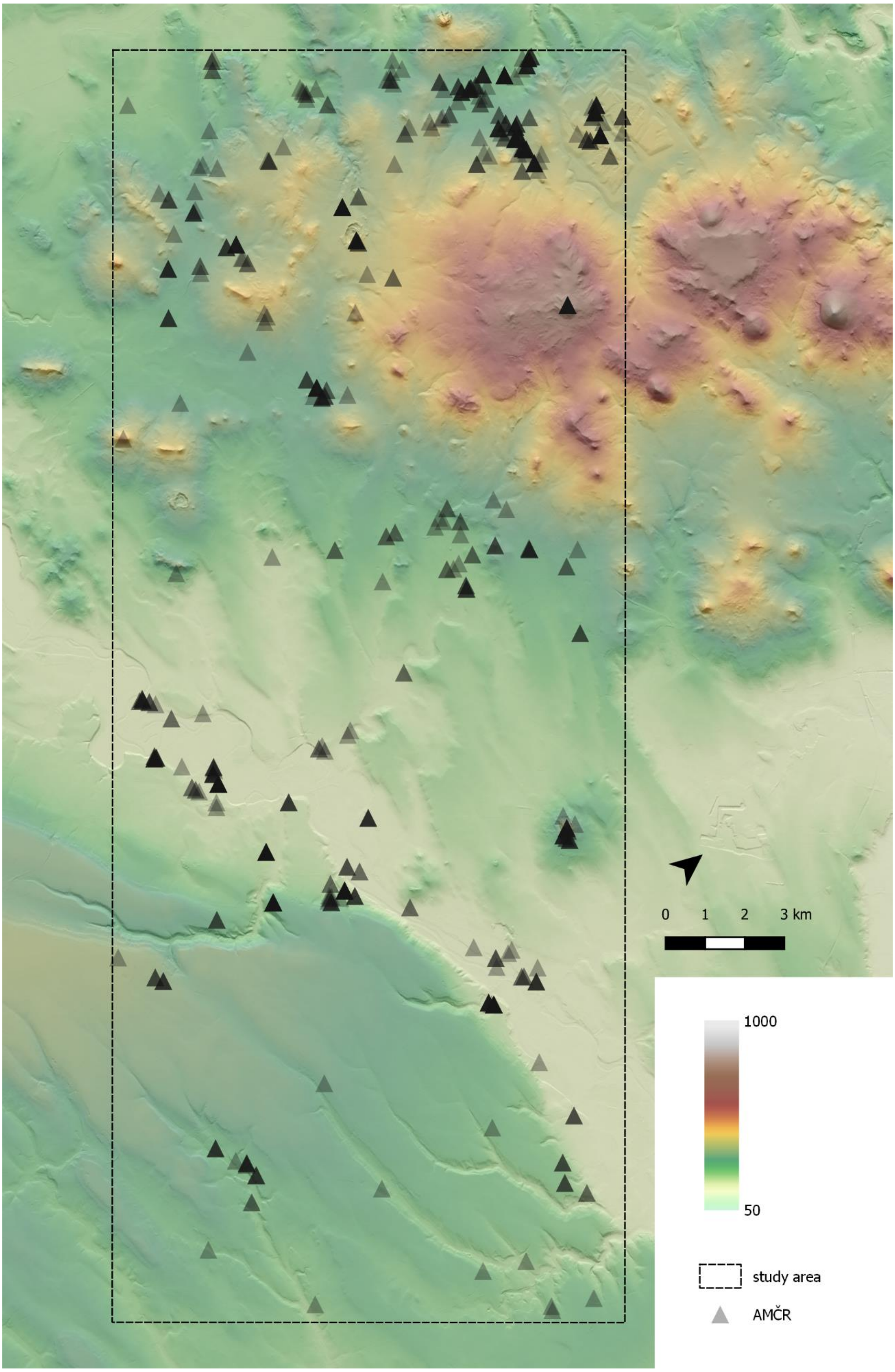
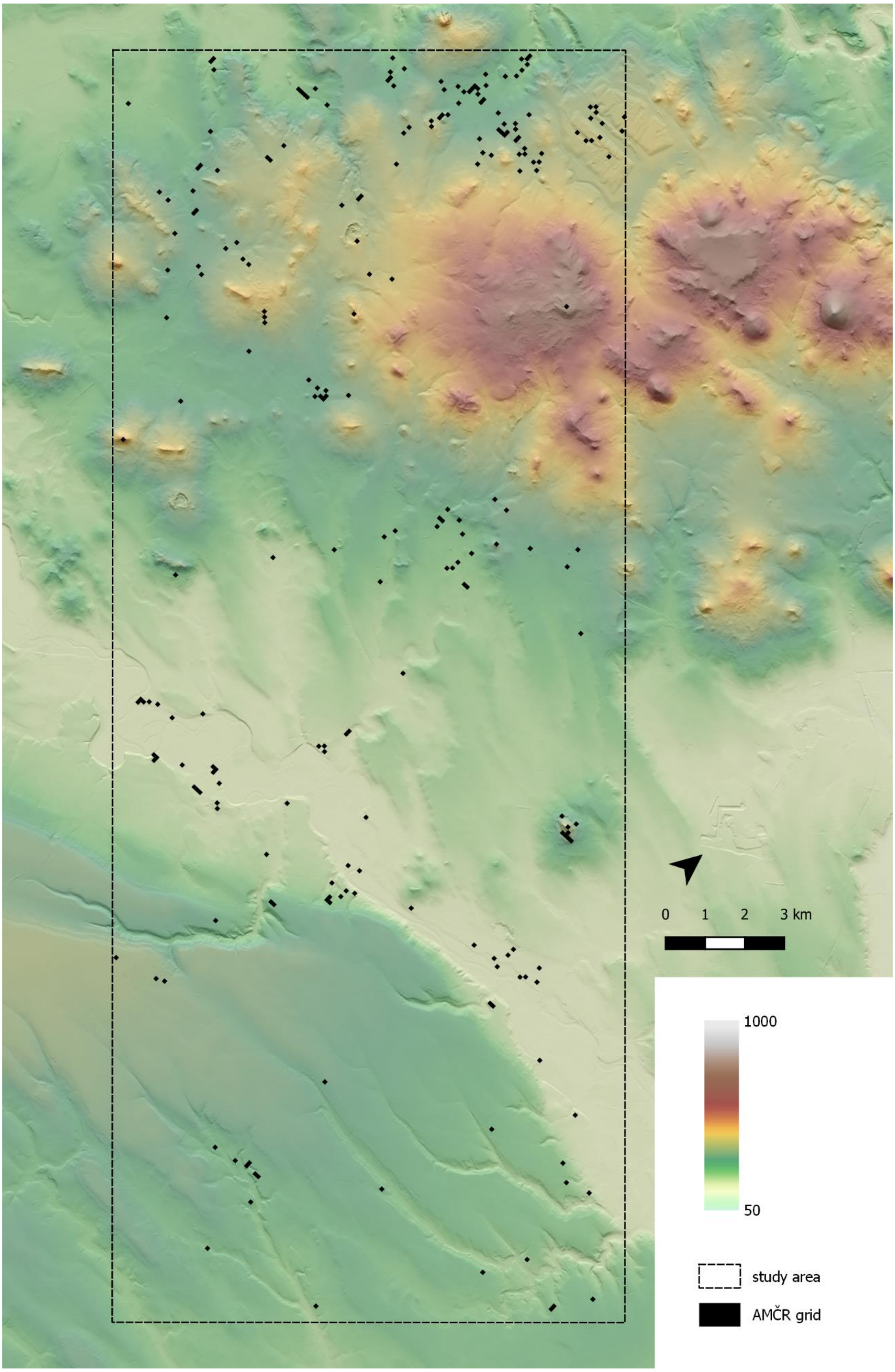


Fig. 6.8: AMČR records converted into grid. Basemap DMR 5G (ČÚZK a [online]).



## 7. Temporal distribution of data

There are various approaches to grasping and depicting temporal distribution of archaeological evidence. Their use depends on the nature of the evidence's dating. Archaeological entities might be dated by scientific methods (such as radiocarbon or dendrochronological dating), where temporal probability is represented by normal distribution, or by chrono-typological dating, where periods or uneven lengths are most commonly assigned uniform probability distribution.[9] For radiocarbon data, the summed probability method is widely used as a proxy for temporal distribution (Demján – Dreslerová 2016, 101). Noteworthy also is the multi-proxy approach which can combine both scientifically and chrono-typologically dated evidence and incorporates ecological proxies (most recently e. g. Bergsvig et al. 2021 or Lawrence et al. 2021). It is chrono-typologically dated evidence, however, which is interest of this work. In the uniform probability distribution, every time point within the interval has the same probability value. Methods for analysing temporal distribution of chrono-typologically dated evidence include natural breaks, mid-point method, aoristic analysis, or Monte Carlo simulation (Orton et al. 2017).

With natural breaks, intervals of uneven lengths are appointed. Counted cases for each interval are displayed as discrete entities usually along an ordinal axis. Modification of this approach is representation by ratio of counts to the length of a phase, rather than count itself (e. g. Dreslerová – Pokorný 2004). The greatest disadvantage of this method is the inability to deal with overlapping phases.

Alternatively, rather than whole phases, mid-points of intervals might be assigned. At the timescale divided into uniform arbitrary units (e. g. decades, centuries, millennia) points belonging to each division are counted. The mid-points method offers a good tool to represent the frequency of the past events if the original expected interval of an event's occurrence lies entirely within one arbitrary time unit, but becomes problematic for intervals overlapping more units, due to length, or position. Events dated within long intervals have a high chance of being assigned into intervals when the event in fact did not happen. So called aoristic analysis (Ratcliffe 2000) also appoints a timescale divided into arbitrary uniform units. However, instead of appointing mid-points, the whole chronological phase is assigned the probability of 1 with uniform

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[9] Although currently used absolute dates of beginnings and ends of intervals assigned to chrono-typological dating are not strictly independent from scientific dating but result from models which assign absolute dating (direct or based on context) of some members to the larger groups.

probability distribution. The assumption is that the event must have happened within the duration of the phase. The volume of probability belonging to each arbitrary time unit is then calculated and summed for each interval. In interpretation, aoristic sum is generally considered as an estimate of frequency, but it also incorporates distribution of probability and does not allow for measurement of uncertainty (Crema 2012, Orton et al. 2017). In awareness of this shortcoming of aoristic analysis, the use of Monte Carlo simulation was proposed by E. Crema (2012). Within the most basic application of this approach, every event of evidence is assigned a random point of occurrence from its dating interval based on probability distribution, and the process is repeated numerous times. Then the frequencies of occurrences are summarized. To compare the significance of observed time frequencies to random distribution, a null model is created. The simplest null model assigns every observation a random time point from the whole time period of study. Alternatively, an exponential curve representing loss of record over time might be used for a null model. For environmental samples, volume of sampled material might be incorporated into the model (Crema 2012, Orton et. al 2017). For the purpose of this work, aoristic analysis and Monte Carlo simulation were appointed.

There are available tools for Monte Carlo simulation and aoristic analysis in archaeology, notably, archSeries package for R (Orton et al. 2017). However, for adjustment of spatial aspect of the data (filtering of duplicate grid cells), computation operations were written in R language (version R-4.1.0) by the author of this work and carried out in the RStudio desktop environment. Used code is available in the supplement of this work.

## 7.1 Application of aoristic analysis

All dating intervals of archaeological record appointed to all squares were given probability of 1 with uniform distribution. This volume was overlaid with a timescale of arbitrary time intervals (bins) of 100 and 400 years which corresponded with the beginning and end of whole period studied. The part belonging to each bin was calculated in the following step. Only parts with greatest volume for each square and bin were summed - representing only the most precise dating interval for the particular bin and grid cell. The process was repeated for ALRNB, AMČR data and combined dataset. In the combined dataset 5 duplicate components were filtered out beforehand. Both representation by simple aoristic sum and Monte Carlo simulation are sensitive to the chosen time intervals. Figure 7.1 demonstrates the difference for 100-year and 400-year intervals.

### 7.2 Application of Monte Carlo simulation

Records for squares were appointed a random year from the dating interval. In the following step the year was connected to the responding arbitrary intervals of 100 and 400 years – bins which corresponded to the beginning and end of centuries. The results were filtered and identical bins belonging to the same square within one simulation were removed. Only presence or absence of bin interval within a grid cell was counted. The resulting figure represents the number of occupied cells. This process was repeated 2000 times. Minimums, maximums, mean and 90 % confidence intervals were calculated. 90 % confidence intervals were calculated also for null model, where all records were distributed to the whole period studied.

### 7.3 Results

Within 100-years resolution, for the beginning of the studied time interval, the Neolithic (5600 BC to 4200 BC), decrease towards the end of the period in the ALRNB data did not exceed randomly distributed model. Coarse 400-years resolution on the other hand suggested gradual decrease for ALRNB dataset.

The period of 4200 BC to 2300 BC containing most of the Eneolithic showed a decrease for the ALRNB dataset visible in both 100 and 400-years resolution. And either decrease or absence of trends for the AMČR data for 100-yers resolution and decrease for broader time intervals.

Stable counts of occupied squares without significant increases or decreases were shown within the 100-years resolution for the first half of the Bronze Age from 2300 BC to 1300 BC).

The most significant increase of evidence for agricultural prehistory belonged largely to the LBA, namely between 1200 BC and 1000 BC (respective FBA and 900 BC for AMČR).

AMČR data showed an increase of occupied squares for the Hallstatt period in (time interval 500 BC to 400 BC), but the increase was not significant for ALRNB data.

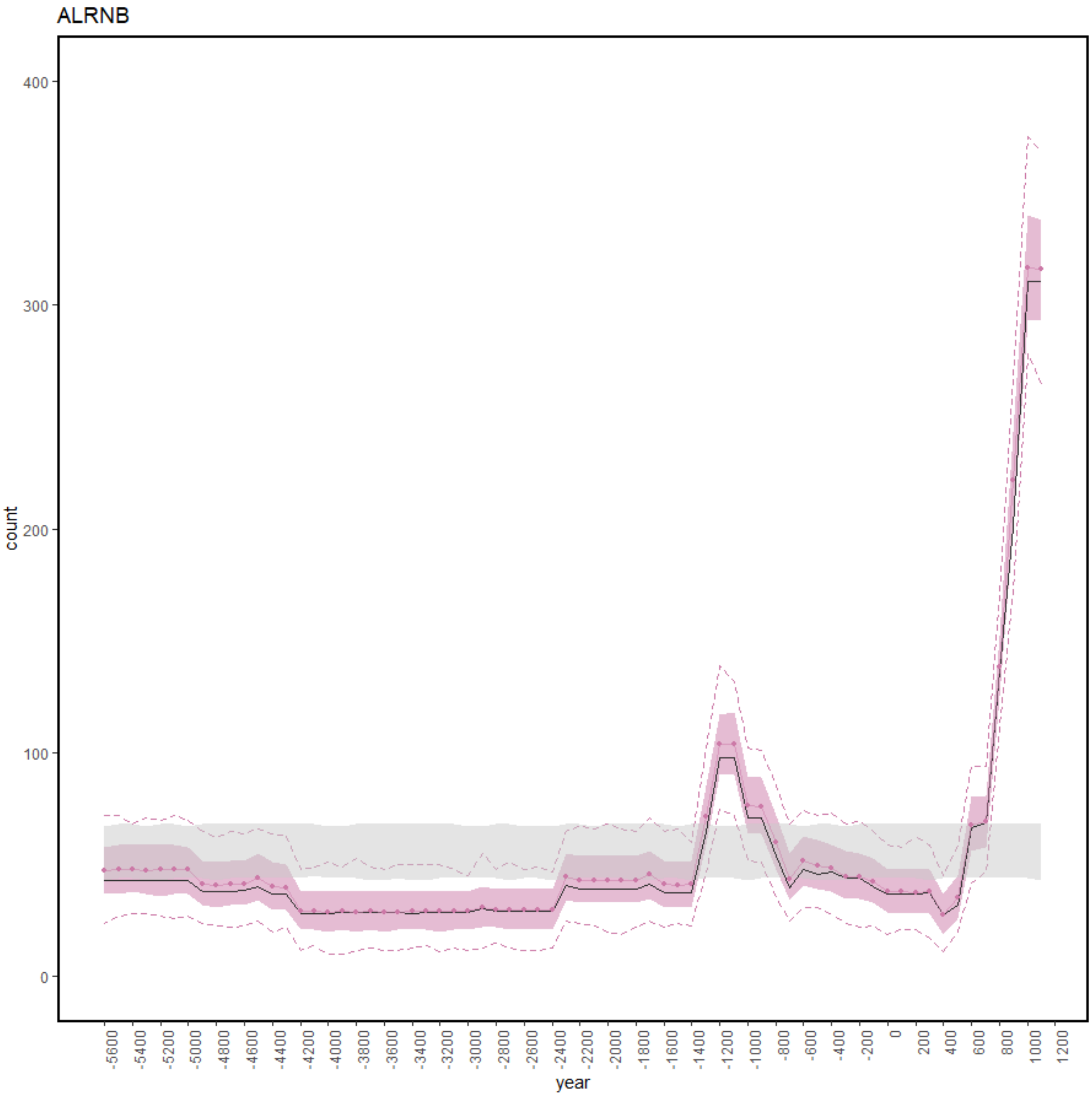
Within ALRNB, a significant decrease could be noticed between 400 AD and 600 AD representing largely the Migration period.

EMA from 800 AD resp. 900 AD to 1200 AD showed a visible increase in the recorded evidence, although the overall counts of AMČR did not significantly differ from the previous periods. Comparatively, the growth in the recorded data for ALRNB was exponential.

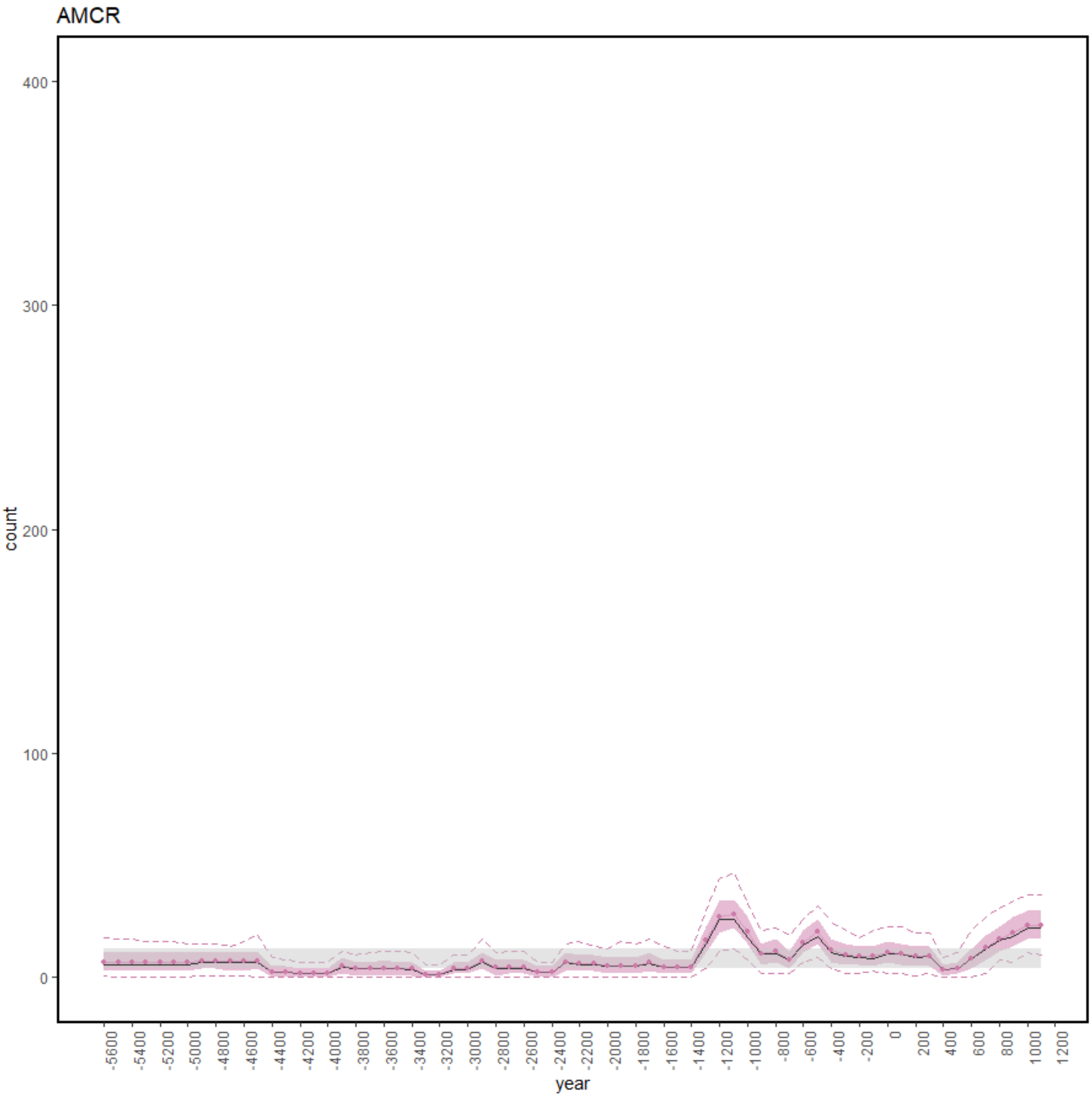
Due to the significant difference in the number of records, the of combined sources followed distribution of larger ALRNB dataset Figure 7.1c, 7.1f.

Fig. 7.1: Temporal distribution of occupied squares. Aoristic sum and Monte Carlo simulation in 1. 100-years and 2. 400-years resolution. Black line represents aoristic sum. Coloured band shows 90 % confidence interval for Monte Carlo simulation. Coloured line and points depict mean for Monte Carlo simulation. Dashed coloured line envelopes all simulations. Grey band shows 90 % confidence interval for simulation of null model. Monte Carlo simulations were based upon 2000 runs.

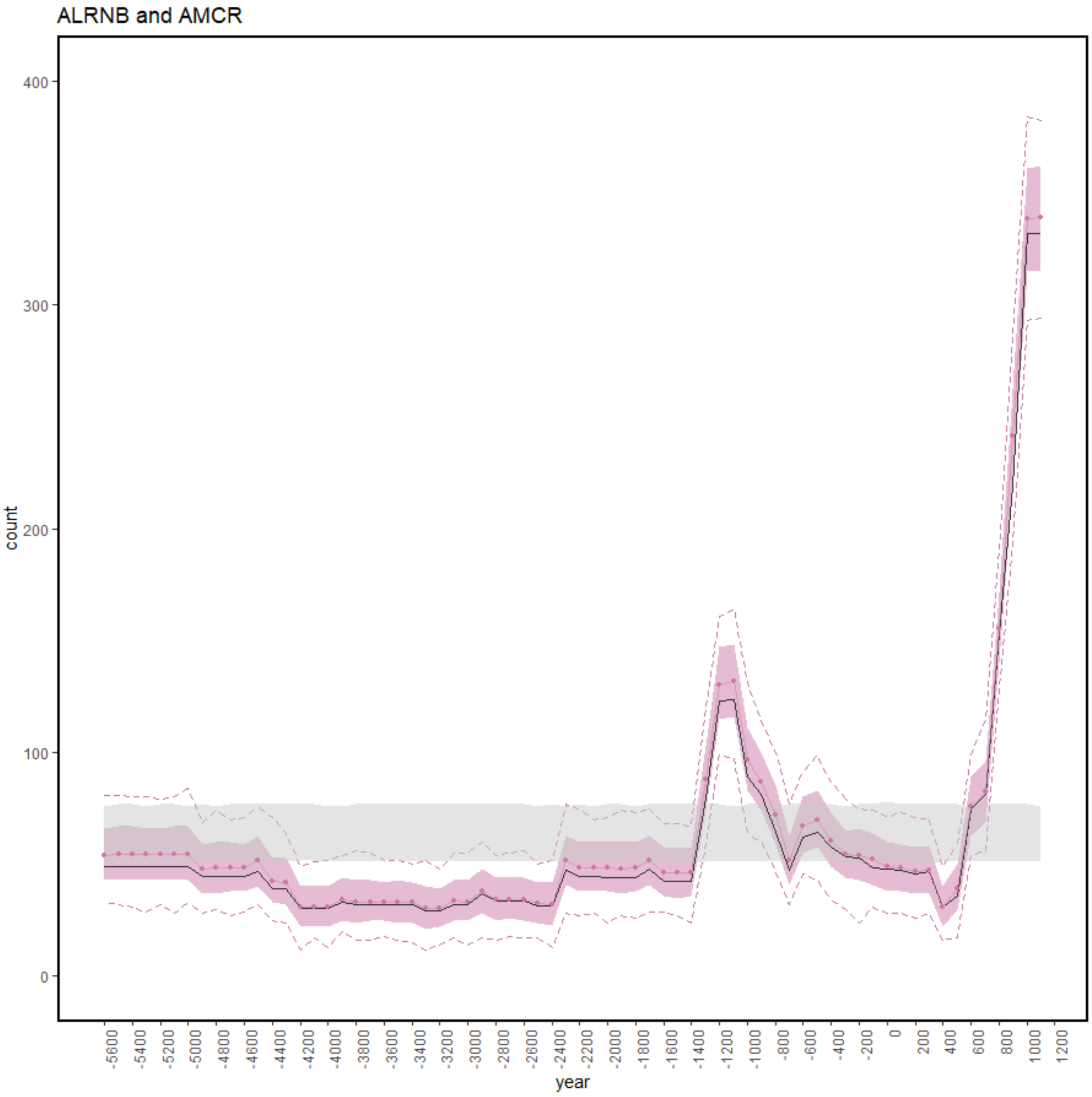
7.1a: ALRNB 100-years intervals.



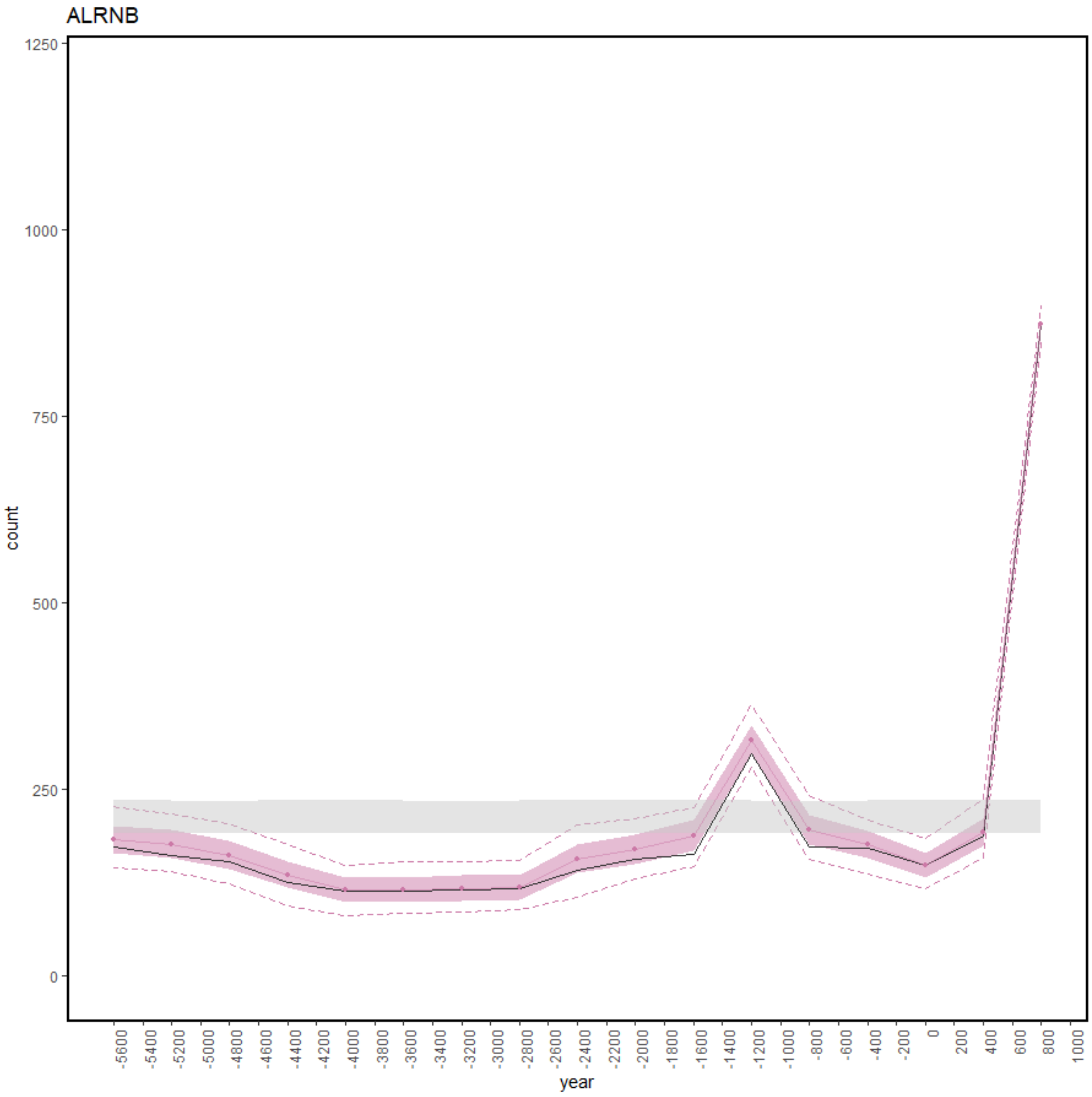
7.1b: AMČR 100-years intervals.



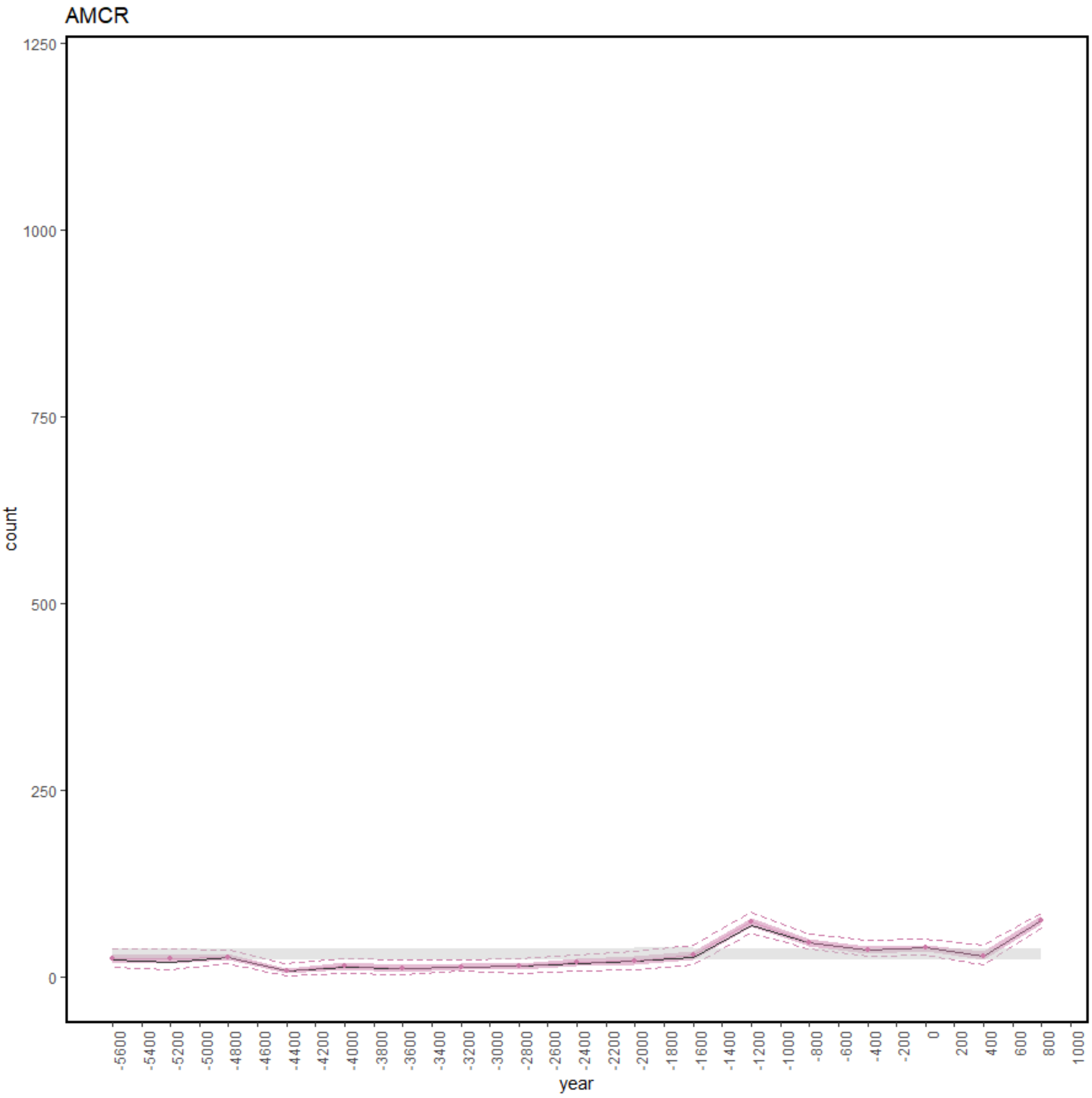
7.1c: Combined data 100-years intervals.



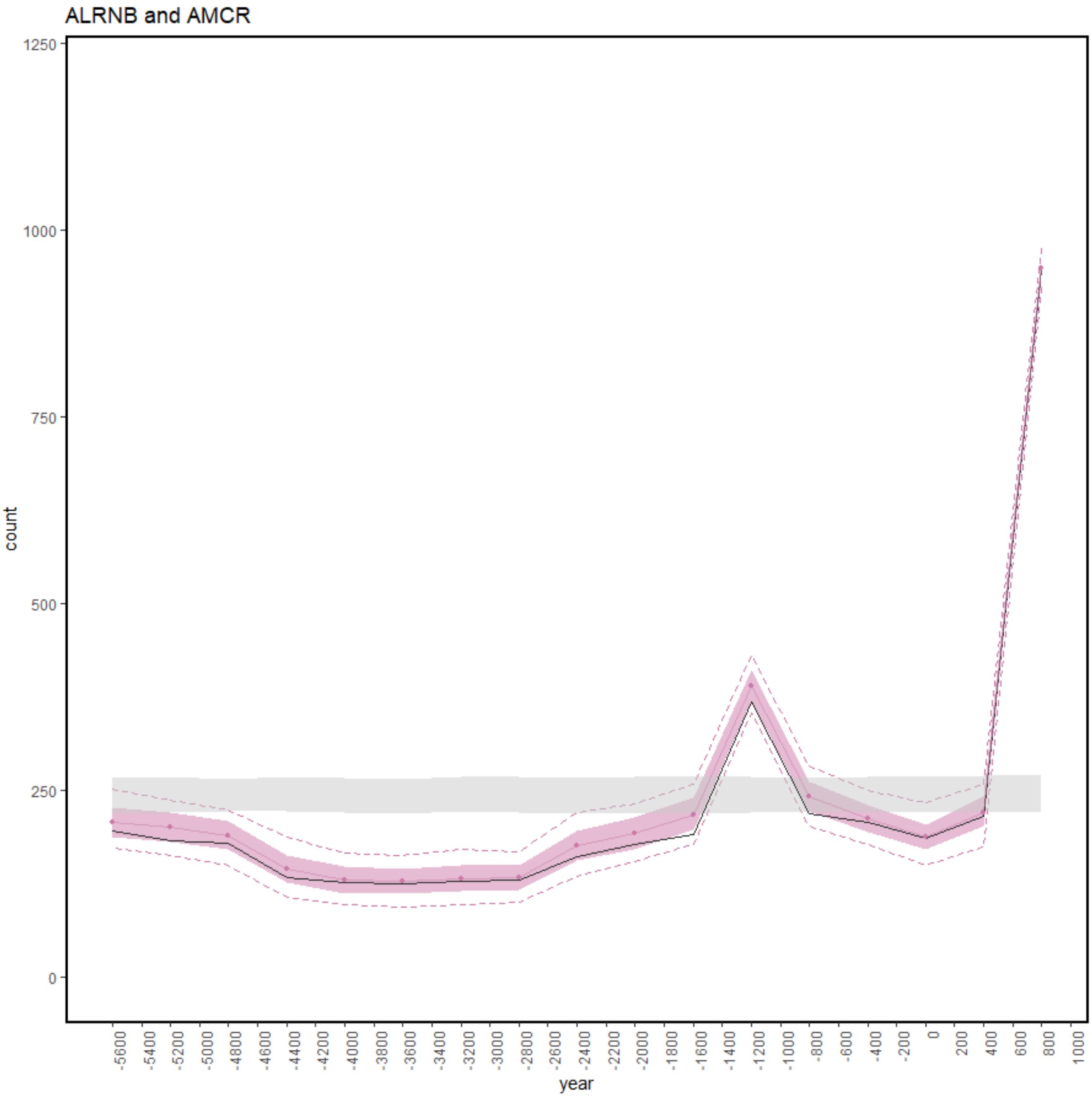
7.1d: ALRNB 400-years intervals.



7.1e: AMČR 400-years intervals



7.1f: Combined data 400-years intervals.



## 8. Continuity

Aoristic sum was utilised to assess continuity and spatial correlation of settlement from different periods. Long dating intervals would overestimate correlation between subsequent time slices where weight of one component with fixed coordinates was redistributed to more time intervals. To lessen this bias, longer 400-yeas intervals were chosen with the disadvantage of lessening the resolution of the model. The problem of uneven length of chrono-typological phases is present in most of the approaches dealing with continuity in archaeological record. If we assume that components represent events of comparable temporal length, e. g. duration of settlement, widening of the dating interval enlarges the chance that the event did not belong close to the shared margin of two subsequent time intervals. Narrow time intervals, on the other hand, might create artificial breaks between events with relatively high temporal proximity, although this might be compensated with lessening of temporal resolution or use of interpolation.

In order to incorporate the continuity of spatially close components, the Gaussian filter with radius of 300 m, and standard deviation of 1 was applied in GIS environment to redistribute the assigned aoristic weights by Gaussian distribution to the neighbouring areas.

Continuity was assessed as the multiple of probabilistic weights of the filtered values for each location in GIS environment with the use of raster algebra tools. In order to compensate different volume of record for the considered periods, results were expressed as a percentage of sum of multiplied weight raster to the sum of weights of compared time rasters representing the time intervals.

### 8.1 Results

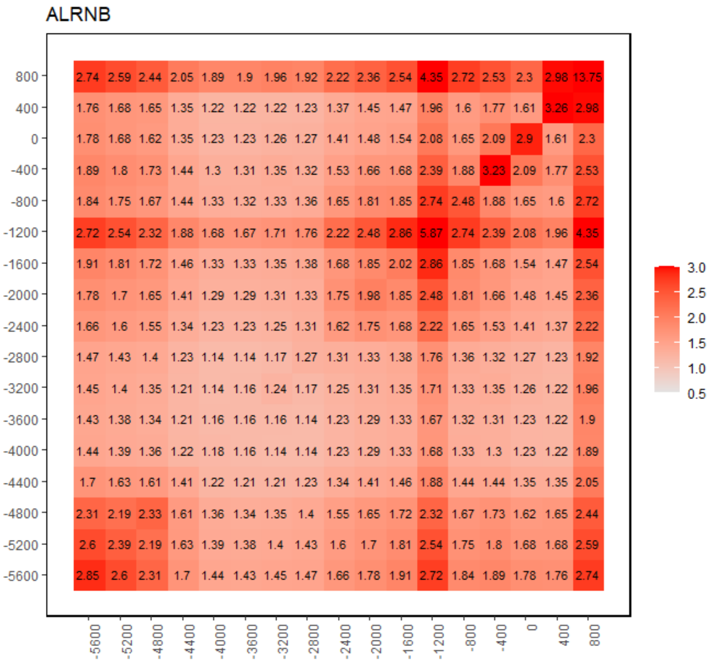
For the ALRNB record strong spatial correlation was observed among three Neolithic intervals from 5600–5200 BC, 5200–4800 BC and 4800–4400 BC. Intervals of 1200-800 BC and 800–1200 AD with overall high aoristic sums correlated with all observed periods. Minimal spatial overlap was observed for Eneolithic.

Time intervals assigned to Neolithic correlated with each other also in the AMČR dataset. Further, spatial relationship was observed between Neolithic and periods of 1200 BC to 400 AD and 800–400 BC with 800–1200 AD.

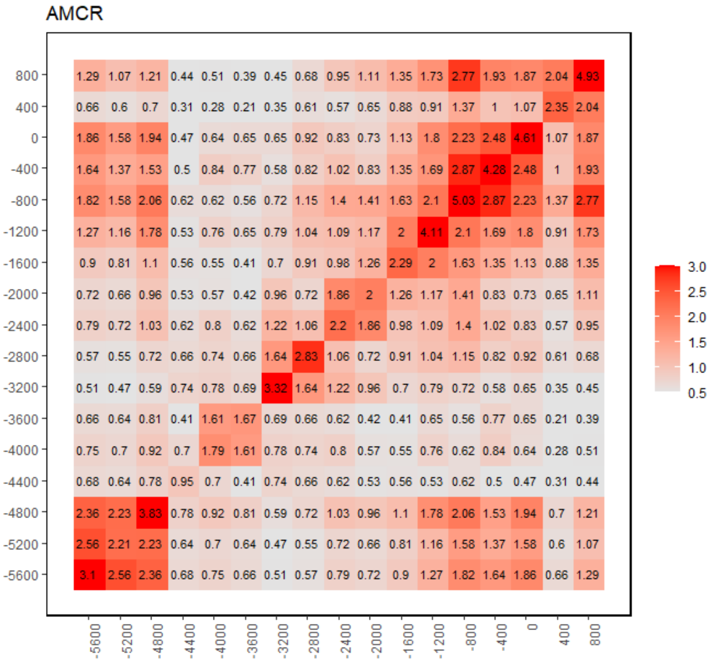
Comparing subsequent 400 years intervals AMČR data showed greater fluctuation. In both datasets stronger spatial correlation was observed for Neolithic and

EMA. In ALRNB data strong correlation showed between 1600-1200 BC, and 1200-800BC to following intervals. For AMČR stronger connection was observed for intervals 800-400 BC and 400BC-0.

Fig. 8.1: Spatial overlap of all periods as multiple of aoristic weights compared to sum of weights (%).

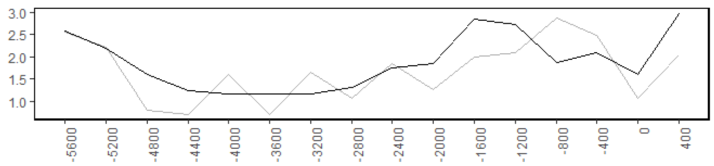


| | -5600 | -5200 | -4800 | -4400 | -4000 | -3600 | -3200 | -2800 | -2400 | -2000 | -1600 | -1200 | -800 | -400 | 0 | 400 | 800 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 800 | 2.74 | 2.59 | 2.44 | 2.05 | 1.89 | 1.9 | 1.96 | 1.92 | 2.22 | 2.36 | 2.54 | 4.35 | 2.72 | 2.53 | 2.3 | 2.98 | 13.75 |
| 400 | 1.76 | 1.68 | 1.65 | 1.35 | 1.22 | 1.22 | 1.22 | 1.23 | 1.37 | 1.45 | 1.47 | 1.96 | 1.6 | 1.77 | 1.61 | 3.26 | 2.98 |
| 0 | 1.78 | 1.68 | 1.62 | 1.35 | 1.23 | 1.23 | 1.26 | 1.27 | 1.41 | 1.48 | 1.54 | 2.08 | 1.65 | 2.09 | 2.9 | 1.61 | 2.3 |
| -400 | 1.89 | 1.8 | 1.73 | 1.44 | 1.3 | 1.31 | 1.35 | 1.32 | 1.53 | 1.66 | 1.68 | 2.39 | 1.88 | 3.23 | 2.09 | 1.77 | 2.53 |
| -800 | 1.84 | 1.75 | 1.67 | 1.44 | 1.33 | 1.32 | 1.33 | 1.36 | 1.65 | 1.81 | 1.85 | 2.74 | 2.48 | 1.88 | 1.65 | 1.6 | 2.72 |
| -1200 | 2.72 | 2.54 | 2.32 | 1.88 | 1.68 | 1.67 | 1.71 | 1.76 | 2.22 | 2.48 | 2.86 | 5.87 | 2.74 | 2.39 | 2.08 | 1.96 | 4.35 |
| -1600 | 1.91 | 1.81 | 1.72 | 1.46 | 1.33 | 1.33 | 1.35 | 1.38 | 1.68 | 1.85 | 2.02 | 2.86 | 1.85 | 1.68 | 1.54 | 1.47 | 2.54 |
| -2000 | 1.78 | 1.7 | 1.65 | 1.41 | 1.29 | 1.29 | 1.31 | 1.33 | 1.75 | 1.98 | 1.85 | 2.48 | 1.81 | 1.66 | 1.48 | 1.45 | 2.36 |
| -2400 | 1.66 | 1.6 | 1.55 | 1.34 | 1.23 | 1.23 | 1.25 | 1.31 | 1.62 | 1.75 | 1.68 | 2.22 | 1.65 | 1.53 | 1.41 | 1.37 | 2.22 |
| -2800 | 1.47 | 1.43 | 1.4 | 1.23 | 1.14 | 1.14 | 1.17 | 1.27 | 1.31 | 1.33 | 1.38 | 1.76 | 1.36 | 1.32 | 1.27 | 1.23 | 1.92 |
| -3200 | 1.45 | 1.4 | 1.35 | 1.21 | 1.14 | 1.16 | 1.24 | 1.17 | 1.25 | 1.31 | 1.35 | 1.71 | 1.33 | 1.35 | 1.26 | 1.22 | 1.96 |
| -3600 | 1.43 | 1.38 | 1.34 | 1.21 | 1.16 | 1.16 | 1.16 | 1.14 | 1.23 | 1.29 | 1.33 | 1.67 | 1.32 | 1.31 | 1.23 | 1.22 | 1.9 |
| -4000 | 1.44 | 1.39 | 1.36 | 1.22 | 1.18 | 1.16 | 1.14 | 1.14 | 1.23 | 1.29 | 1.33 | 1.68 | 1.33 | 1.3 | 1.23 | 1.22 | 1.89 |
| -4400 | 1.7 | 1.63 | 1.61 | 1.41 | 1.22 | 1.21 | 1.21 | 1.23 | 1.34 | 1.41 | 1.46 | 1.88 | 1.44 | 1.44 | 1.35 | 1.35 | 2.05 |
| -4800 | 2.31 | 2.19 | 2.33 | 1.61 | 1.36 | 1.34 | 1.35 | 1.4 | 1.55 | 1.65 | 1.72 | 2.32 | 1.67 | 1.73 | 1.62 | 1.65 | 2.44 |
| -5200 | 2.6 | 2.39 | 2.19 | 1.63 | 1.39 | 1.38 | 1.4 | 1.43 | 1.6 | 1.7 | 1.81 | 2.54 | 1.75 | 1.8 | 1.68 | 1.68 | 2.59 |
| -5600 | 2.85 | 2.6 | 2.31 | 1.7 | 1.44 | 1.43 | 1.45 | 1.47 | 1.66 | 1.78 | 1.91 | 2.72 | 1.84 | 1.89 | 1.78 | 1.76 | 2.74 |



| | -5600 | -5200 | -4800 | -4400 | -4000 | -3600 | -3200 | -2800 | -2400 | -2000 | -1600 | -1200 | -800 | -400 | 0 | 400 | 800 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 800 | 1.29 | 1.07 | 1.21 | 0.44 | 0.51 | 0.39 | 0.45 | 0.68 | 0.95 | 1.11 | 1.35 | 1.73 | 2.77 | 1.93 | 1.87 | 2.04 | 4.93 |
| 400 | 0.66 | 0.6 | 0.7 | 0.31 | 0.28 | 0.21 | 0.35 | 0.61 | 0.57 | 0.65 | 0.88 | 0.91 | 1.37 | 1 | 1.07 | 2.35 | 2.04 |
| 0 | 1.86 | 1.58 | 1.94 | 0.47 | 0.64 | 0.65 | 0.65 | 0.92 | 0.83 | 0.73 | 1.13 | 1.8 | 2.23 | 2.48 | 4.61 | 1.07 | 1.87 |
| -400 | 1.64 | 1.37 | 1.53 | 0.5 | 0.84 | 0.77 | 0.58 | 0.82 | 1.02 | 0.83 | 1.35 | 1.69 | 2.87 | 4.28 | 2.48 | 1 | 1.93 |
| -800 | 1.82 | 1.58 | 2.06 | 0.62 | 0.62 | 0.56 | 0.72 | 1.15 | 1.4 | 1.41 | 1.63 | 2.1 | 5.03 | 2.87 | 2.23 | 1.37 | 2.77 |
| -1200 | 1.27 | 1.16 | 1.78 | 0.53 | 0.76 | 0.65 | 0.79 | 1.04 | 1.09 | 1.17 | 2 | 4.11 | 2.1 | 1.69 | 1.8 | 0.91 | 1.73 |
| -1600 | 0.9 | 0.81 | 1.1 | 0.56 | 0.55 | 0.41 | 0.7 | 0.91 | 0.98 | 1.26 | 2.29 | 2 | 1.63 | 1.35 | 1.13 | 0.88 | 1.35 |
| -2000 | 0.72 | 0.66 | 0.96 | 0.53 | 0.57 | 0.42 | 0.96 | 0.72 | 1.86 | 2 | 1.26 | 1.17 | 1.41 | 0.83 | 0.73 | 0.65 | 1.11 |
| -2400 | 0.79 | 0.72 | 1.03 | 0.62 | 0.8 | 0.62 | 1.22 | 1.06 | 2.2 | 1.86 | 0.98 | 1.09 | 1.4 | 1.02 | 0.83 | 0.57 | 0.95 |
| -2800 | 0.57 | 0.55 | 0.72 | 0.66 | 0.74 | 0.66 | 1.64 | 2.83 | 1.06 | 0.72 | 0.91 | 1.04 | 1.15 | 0.82 | 0.92 | 0.61 | 0.68 |
| -3200 | 0.51 | 0.47 | 0.59 | 0.74 | 0.78 | 0.69 | 3.32 | 1.64 | 1.22 | 0.96 | 0.7 | 0.79 | 0.72 | 0.58 | 0.65 | 0.35 | 0.45 |
| -3600 | 0.66 | 0.64 | 0.81 | 0.41 | 1.61 | 1.67 | 0.69 | 0.66 | 0.62 | 0.42 | 0.41 | 0.65 | 0.56 | 0.77 | 0.65 | 0.21 | 0.39 |
| -4000 | 0.75 | 0.7 | 0.92 | 0.7 | 1.79 | 1.61 | 0.78 | 0.74 | 0.8 | 0.57 | 0.55 | 0.76 | 0.62 | 0.84 | 0.64 | 0.28 | 0.51 |
| -4400 | 0.68 | 0.64 | 0.78 | 0.95 | 0.7 | 0.41 | 0.74 | 0.66 | 0.62 | 0.53 | 0.56 | 0.53 | 0.62 | 0.5 | 0.47 | 0.31 | 0.44 |
| -4800 | 2.36 | 2.23 | 3.83 | 0.78 | 0.92 | 0.81 | 0.59 | 0.72 | 1.03 | 0.96 | 1.1 | 1.78 | 2.06 | 1.53 | 1.94 | 0.7 | 1.21 |
| -5200 | 2.56 | 2.21 | 2.23 | 0.64 | 0.7 | 0.64 | 0.47 | 0.55 | 0.72 | 0.66 | 0.81 | 1.16 | 1.58 | 1.37 | 1.58 | 0.6 | 1.07 |
| -5600 | 3.1 | 2.56 | 2.36 | 0.68 | 0.75 | 0.66 | 0.51 | 0.57 | 0.79 | 0.72 | 0.9 | 1.27 | 1.82 | 1.64 | 1.86 | 0.66 | 1.29 |

Fig. 8.2: Continuity for subsequent time intervals. Black line stands for ALRNB, grey for AMČR.



## 9. Settlement activity and natural environment

It is impossible to evaluate most of the past environmental attributes directly, instead proxies of the current era are appointed, showing relative distribution of better and less favourable conditions which is considered to correspond with past environmental patterns (Dreslerová – Demján 2015, 151). Terrain is considered as the most stable part of the environment. However, as the area north of the study transect heavily disturbed by coal mining demonstrates, there are exceptions to this rule.

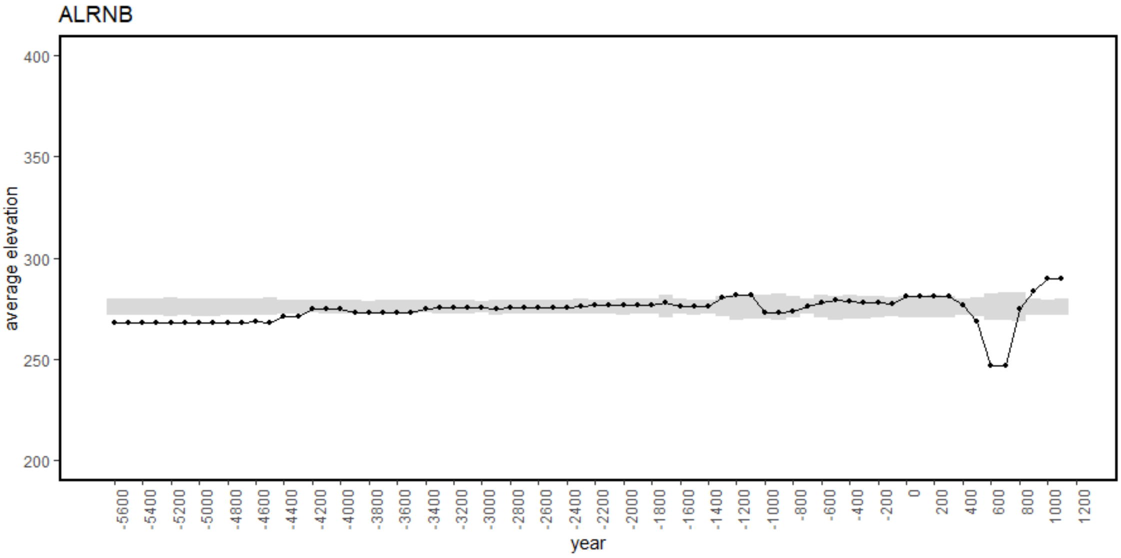
Three environmental factors were considered: elevation, distance from the water sources and fertility of soils. Aoristic weights assigned to arbitrary uniform time intervals from the modelled temporal distribution were used to assess the environmental attributes. Values, either calculated as averages for spatial analytical units (100 m squares) or sampled from centroids, were compared to random distribution of the same dataset.

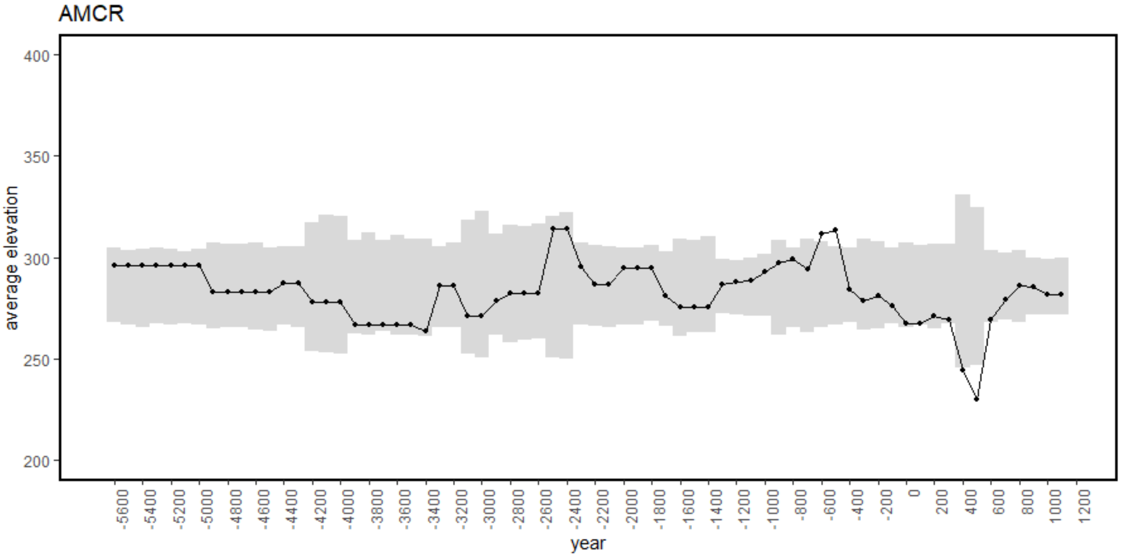
### 9.1 Elevation

Elevation was calculated for each square in GIS from the digital terrain model DMR 5G (ČÚZK a [online]) by use of a zonal statistics function. Weighted average was gained from aoristic weights appointed to squares and 100-year time intervals. Second, randomly distributed dataset for comparison was created by random assignment of the same values to the identical bins and weights in 1000 simulations.

As would be expected based on different fieldwork methods, the AMČR dataset displayed greater variability and more fluctuations, although generally not outside of envelope of the random dataset (Fig. 9.1). Within ALRNB data there was notably low average elevation for the Neolithic, which was not reflected in the AMČR record. ALRNB showed lowest average elevation for the Migration period and EMA 1 and 2, between 500–800 AD, and AMČR for 300 AD to 700 AD. The peaks were less visible 1300 BC to 1000 BC in ALRNB and 600 BC to 400 BC for the AMČR record. Significant increase of average elevation visible in EMA 3 and EMA 4 in ALRNB database was not reflected in the AMČR record.

Fig. 9.1 Average elevation. Black line represents weighted average of elevation for 100-years time intervals. Grey area shows 90 % confidence envelope for randomly assigned values simulated by 1000 runs.



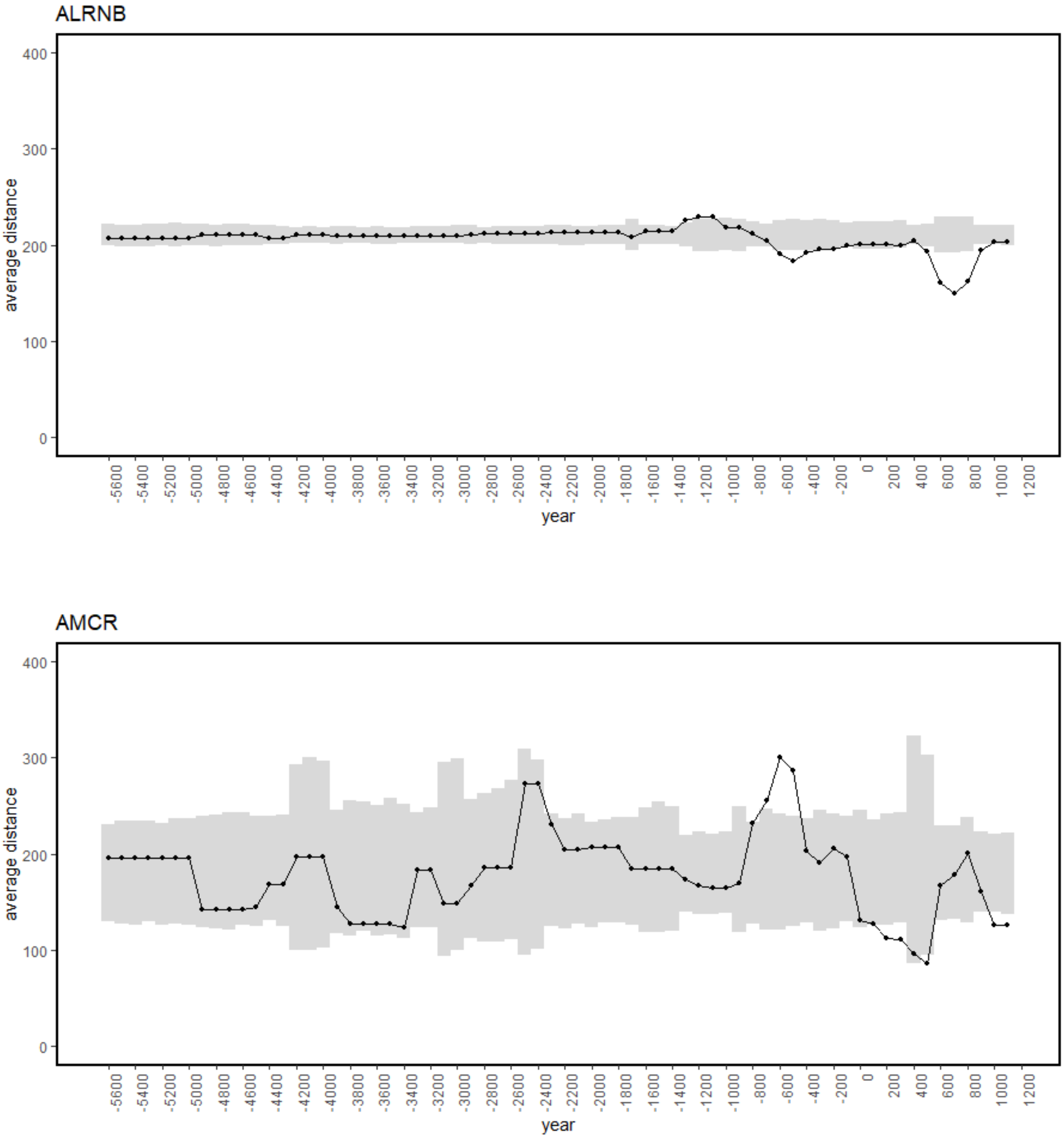


## 9.2 Distance from the nearest water source

In archaeology, past water sources are generally modelled from old maps, based on terrain models, or the location of fluvial sediments is used as a proxy. In this work fluvial sediments vectorised from the Geological map of the Czech Republic 1:50 000 (Česká geologická služba[online]) were chosen to calculate the distance raster in GIS. Neither fluvial sediments, nor terrain-based models are able to catch small local sources, yet we do believe that the chosen method is able to demonstrate general trends in settlement. Values for analytical units and 100-year time intervals were calculated by use of zonal statistics. Weighted average based on aoristic weights was compared to 90 % confidence envelope of the same values randomly assigned to identic bins and weight in 1000 simulations.

The AMČR dataset again showed more fluctuation. In contrast to lower average elevations in the Neolithic, ALRNB data did not show significantly lower average distance from the nearest water sources. Higher values were observed for 1300–1000 BC and lower for 700–500 BC. No increase comparable to increase of average elevation for EMA 3 and EMA 4 was observed. Significant increase of average distance from the nearest water source appeared in 800–400 BC in AMČR data.

Fig. 9.2 Average distance from the nearest water source. Black line represents weighted average of distance in metres for 100-years time intervals. Grey area shows 90 % confidence envelope for randomly assigned values simulated by 1000 runs.

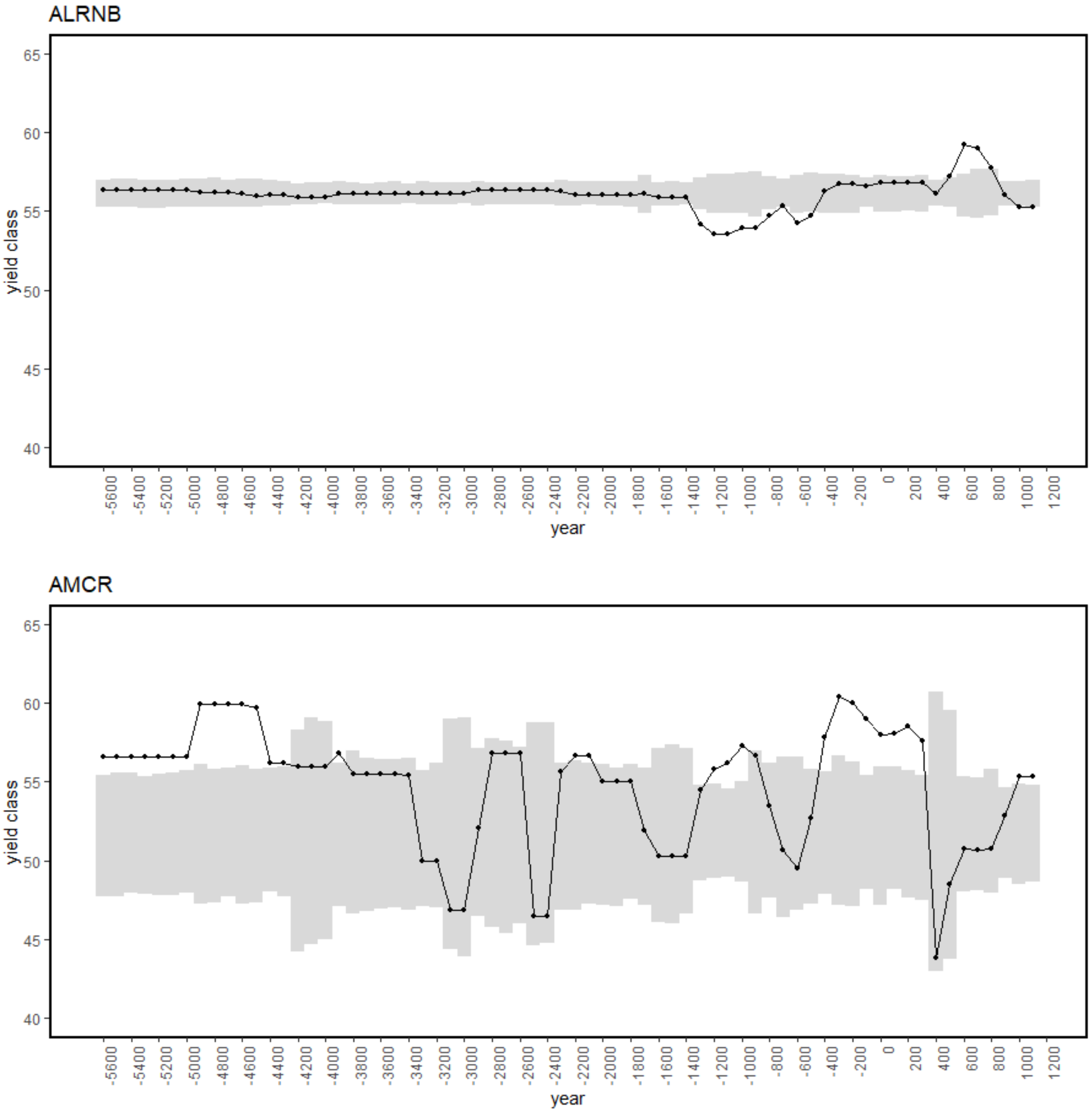


### 9.3 Soils

The yield scale used in the Czech Republic to classify agricultural soils was chosen as a proxy of past distribution of less and more suitable soils. The scale ranges from 6 to 100, with larger numbers standing for more fertile soils. The yield is calculated based on BPEJ (*Bonitované půdně ekologicé jednotky*) index which aggregates various factors including climatic region, chemical and mechanical soil attributes, soil depth, slope, and aspect (VÚMOP [online]). BPEJ is not assigned to all areas. Records without assigned value (34 for ALRNB and 88 for AMČR) were excluded from the analysis. For the rest of the spatial analytical units, soil class was attributed to squares' centroids. As with the previous environmental factors, weighted average based on aoristic weights was compared to randomly assigned values.

Preference for more fertile soils was observed in AMČR data for most of the Neolithic, for the Bronze Age from 1300 BC to 900 BC, and the Roman period. The results did not correlate with ALRNB data where the highest average of soil class was observed for part of the Migration period and EMA from 500 AD to 900 AD. Surprisingly, shift to less fertile soils observed in the ALRNB data was contrasted with more fertile soils for AMČR, even though ALRNB is expected to represent predominantly residential components while all components were included in the second dataset.

Fig. 9.3 Average of yield class. Black line represents weighted average for 100-years time intervals. Grey area shows 90 % confidence envelope for randomly assigned values simulated by 1000 runs.



## 10. Discussion

Within this work presence of component within a spatial unit was used to analyse temporal distribution of evidence. Other approaches might operate with direct count of components.

The main trends of the modelled distribution observed in both datasets could be summarized as:

– **Increase** of the area with archaeological evidence for the Late Bronze Age in the interval of **1200 BC – 1000 BC**.
– **Increase** for EMA from **900 AD – 1200 AD**.

Part of the fluctuations was significant in only one of the datasets:

– **Decrease** for **4200 BC – 2300 BC** was clear only in the ALRNB data, while AMČR showed a significant decrease for 100-years resolution only locally.
– **Increase** covering the Late Hallstatt period (time interval **500 BC – 400 BC**) was observed only in the AMČR data.
– **Decrease** in the Migration period (time interval **400 AD – 600 AD**) was visible in the ALRNB record.

The different rate of the increase for EMA in both datasets might represent two opposing research biases. Generally, EMA pottery is considered as less durable (similarly to prehistoric pottery) in comparison to HMA pottery (more in Chapter 4), but the boundary is not strict, while AMČR data might partially reflect the research bias with different approaches and later advancement of medieval archaeology.

Fluctuations significant only in the ALRNB dataset were generally not opposed by AMČR results but shifts in AMČR data were not significantly pronounced due to the limited volume of the record.

There are numerous works concerning changes in the volume of observed archaeological evidence in time in the Czech Republic. Either in comparison with environmental proxies or more focused on the spatial aspect of the record. Although the methods used differ slightly and direct quantitative comparison is not possible, we can still contrast the presented narratives.

The observed distribution curve modelled in this work corresponds well with frequencies of residential components around Vracov lake (circle with 25 km perimeter) in south Moravia, though different temporal resolution must be taken into consideration. The Vracov study worked with wider 500-year intervals from 6000 BC to 1000 AD. As for the component counts, significant decrease of all components for 4000 to 3000 BC was observed, and increases of residential components were recorded for 1500 BC to 1000 BC and 500 AD to 1000 AD. Frequencies of parishes with evidence also did not show evident differences. Vegetation abundances modelled within the Vracov study showed the highest ratio for open land for agricultural prehistory and EMA for 1–500 AD, 6000–5000 BC, and 2500 to 2000 BC, in the listed order. The general trend of decline of coniferous and increase of deciduous woodland taxa was modelled for agricultural prehistory up to the EMA. The maximums of secondary woodland taxa (Betula, Corylus avellana) for the same period was modelled for 4500–3500 BC and 3000–2000 BC (Kolář et al. 2018). The authors interpreted the secondary woodland taxa as possible early forest succession stages not followed by later stages due to human management of the landscape.

The study of and D. Dreslerová and P. Pokorný (2004), aimed to compare palynological and archaeological evidence in a 3 km perimeter from the pollen profile in the middle Elbe area, worked with counts of spatial units with recorded evidence and the ratio of occupied spatial units against the length of the archaeological period. Our own results correspond with the data in the study. After taking into account the varying length of the archaeological periods, there was maximum of observed evidence in the LBA (1250 – 1000 BC), high values were observed for the second half of EMA, and low values for the Migration Period and Eneolithic. The pollen profile beginning in the Eneolithic, which was examined in the study, corresponded better with the picture of the archaeological evidence in the closest perimeter. The MBA/LBA turn showed the most significant change in the character of the pollen profile with the lowest ratio of oak woodlands. The pollen profile of the period was closer to the Middle Ages than rest of the prehistory. Noteworthy were the low primary anthropogenic indicators but high grazing indicators for the Middle Eneolithic. The increase of the grazing indicators after the Late Bronze Age and Hallstatt period was attributed to cumulative changes.

The temporal distribution modelled in this work also largely corresponds with the distribution curve of archaeological evidence from the surface artefact collections from central Bohemia which included the central transect of the ALRNB programme (Dreslerová – Demján 2019). In the mentioned work there was a decrease of observed evidence between ca. 4500–2500, although with some interruptions. Peaks around 1000 and 500 BC and low counts around 500 AD were also noticeable. The AMČR dataset from the same area displayed greater fluctuation for the Eneolithic. The situation was different, however, for the model which avoided conflict of economical hinterlands and incorporated subdividing of the conflicting chronological phases. Low counts of modelled habitation areas were visible for the beginning and end of Eneolithic rather than for the whole period. And although there were still high counts for LBA, high values for EBA and La Tène period were also visible. The authors ascribed the differences between models to the differences in dating precision, especially in the earlier periods.

Considering the above mentioned examples, when the length of chrono-typological dating was included, repeating settlement patterns were observed both for the direct count of evidence and for the occupied area. The situation was different, however, when the temporal phasing based on the conflicting economic areas was taken into consideration.

Additional environmental proxies strengthen the model and might support the different subsistence strategies as is shown in the two examples for the Eneolithic. Pollen analysis was included in the original ALRNB methodology, but was carried out only at a limited scale and remained largely unpublished; it should be considered a priority for future research.

There is an ongoing discussion in archaeology if temporal distributions of either chrono-typologically or absolutely dated evidence could be considered as proxy for past populations (e. g. M. Kuna 2015b, Dreslerová – Demján 2019, Kolář et al. 2018). We take more conservative stance and do not directly link observed fluctuations to past population size, rather we utilize it to assess other attributes of settlement activity.

Strong spatial connection was observed among Neolithic intervals from 5600 to 4400 BC. Other high and low values seemed to follow high and low values of aoristic sums. Overall high values for overlap for 1200–800 BC suggests that the averagely less favourable environmental conditions are likely result of the greater spatial extend of the settlement including wider rather of locations rather than overall shift towards higher elevations.

Correlation of the Neolithic time intervals with each other is again visible in the AMČR dataset as is the correlation of the same periods with1200 BC to 400 AD and 800–400 BC with 800–1200 AD. Taking into account environmental factors for AMČR, preference for better soils is shown from beginning of the Neolithic to 4400 BC and also from 400BC to 400AD, but not for 800–400BC.

The results should be approached with certain caution. Further consideration of length of dating intervals, volume of record for each period and position of arbitrary time intervals should be incorporated into the future models.

Looking at the environmental factors, small size of AMČR record and inclusion of all components could be seen as the cause for greater fluctuations in the dataset. In the AMČR data the observed trends did not correlate across the considered environmental factors, whereas the opposite could be noted for ALRNB. Aside from preference for more favourable conditions in the Neolithic period, the two datasets did not show the same trends.

None of the observed environmental factors showed continuous decrease or increase for the whole studied period, although growing variability might have been masked by averaging the values.

For most of the Neolithic, lower average elevation and better soils were noticeable in ALRNB and AMČR record, respectively.

Slightly higher average elevation and greater average distance from the nearest water source could be noted in the ALRNB data from 1300 BC to 1100 BC. The trend of less favourable conditions was even more pronounced for average yield class

Within the ALRNB dataset in the period predominantly concerning EMA 1 and EMA 2 (500 AD to 800 AD), all considered environmental factors showed preference for more favourable conditions. Aside of a small overlap within average elevation, the similar preferences were not observed in AMČR data.

## 11. Conclusion

Surface artefact collection was in its beginnings strongly associated with the activities of nonprofessional archaeologists. The method had been applied to search for concentrations of artefacts – “sites” understood as points of past activities. However, even in the beginnings, surface artefact collection was tied to the research of microregions in a landscape-scale. With the spread of other non-destructive methods in archaeology, the integration of surface artefact collection with other non-destructivee methods such as geophysical survey and aerial photography became common. Significant methodological shift came with appointment of analytical survey and sampling and move from site-oriented approach to study of artefacts distributions as continuous structures in landscape. Within the more recent decades, GIS and other database tools allowed for processing of larger quantities of data and more effective use of special maps. Data from surface artefact surveys also found its use in construction of archaeological predictive models.

ALRNB landscape-oriented research programme was established in 1990. Aims included topics of settlement and landscape archaeology, implementation of paleoecological and non-destructive methods, and conversion. Fieldwork campaign took place from 1991 to 1995. Study area included two transects in central and northern Bohemia divided into ecozones – ecological units, chosen to represent wide range of habitats. Initially, wider range of non-destructive methods was proposed, but only surface-artefact collection as carried out on a larger scale. Within transects naturally delimited polygons – usually fields, were chosen by random selection, divided into 1ha stints, and surveyed. The clustering of the analytical units was later considered as the main disadvantages of the survey design. The initial critique concerned mostly surface artefact collection as a method and too generally defined aims of the programme. Results for the central transect of the ALRNB programme were published in 1990s and 2000s. The northern transect was published only for the micro-region of Vraný. Spatial correlation of the subsequent periods with the exception of Neolithic was observed. “Cores” as favourable areas of stability on a landscape scale and “hot spots” as local points were described. Clustering was observed along water courses and at confluences. Additionally, dependence upon more favourable environmental conditions was noted. Methodological issues and observations of postdepositional processes were discussed including effect of the season of the field campaign or erosion and accumulation. S. Vencl pointed on insufficiency of ALRNB methodology for assessing stone tools assemblages.

Aside of records from the northern transect of the ALRNB programme, records from AMČR database were used in this work for further analysis. While ALRNB counted more records, 4030 from the Neolithic to EMA 4, compared to 690 for AMČR,

AMČR showed higher ratio of more precisely dated components. Considering the studied period, 44 % of ALRNB records belonged to unspecified agricultural prehistory, compared to 7 % for AMČR. More precisely dated prehistoric components accounted for 25 % of ALRNB and 75 % AMČR records. For ALRNB 31 % records were dated to EMA, compared to 18 % for AMČR

Temporal distribution of archaeological record was modelled by use of aoristic analysis and Monte Carlo simulation. For the 100-years intervals for both datasets increase was observed for the Late Bronze Age (intervals 1200–1000 BC) and EMA (intervals 900–1200 AD). Decrease in the Eneolithic (intervals 4200–2300 BC) and the Migration period (intervals 400–600 AD) was significant only for the ALRNB, and an increase for the Hallstatt period (interval 500–400 BC) appeared only in AMČR record.

Comparing temporal distribution of evidence modelled for other regions of the Czech Republic, largely similar trends were observed for models which used aoristic weights or indexes incorporating length of chrono-typological dating. This appeared both with count of evidence and consideration of occupied area. The results differed when subdivision of phases based on conflicting economic areas was used

Continuity was considered for wider 400-years intervals where probability of settlement activity was represented by filtered aoristic weights. Continuity was assessed as the multiple of probabilistic weights and divided by sum of weights of compared periods to compensate for varying size of occupied area. Neolithic intervals correlated among each other for both datasets. In ARNB data, the strongest correlation with all other periods generally displayed time intervals with overall heigh aoristic weights. In AMČR strong spatial relationship was observed between Neolithic periods and 800 BC to 400 AD and 800–1200 AD.

Although all three environmental factors were interconnected within the conditions of the study area, the results slightly varied within ALRNB data and showed minimal correlation across datasets or within AMČR itself.

## 12. List of the used abbreviations

ALRNB – Ancient Landscape Reconstruction in Northern Bohemia
*BPEJ – Bonitované půdně ekologicé jednotky*
*ADČ – Archeologická databáze Čech*
*AMČR – Archeologická mapa České republiky*
*AÚ SAV – Archeologický ústav Slovenskej akadémie vied*
*AV ČR – Akademie věd České Republiky*
*ČÚZK - Český úřad zeměměřický a katastrální*
*DAI – Deutsches Archäologisches Institut*
EBA – Early Bronze Age
EMA – Early Middle Ages
FBA – Final Bronze Age
GIS – geographic information system
GNSS – Global Navigation Satellite System
HMA – High Middle Ages
MBA – Middle Bronze Age
LBA – Late Bronze Age
*SAS – Státní archeologický seznam*
*S-JTSK – Systém jednotné trigonometrické sítě katastrální*
*VÚMOP – Výzkumný ústav meliorací a ochrany půdy*

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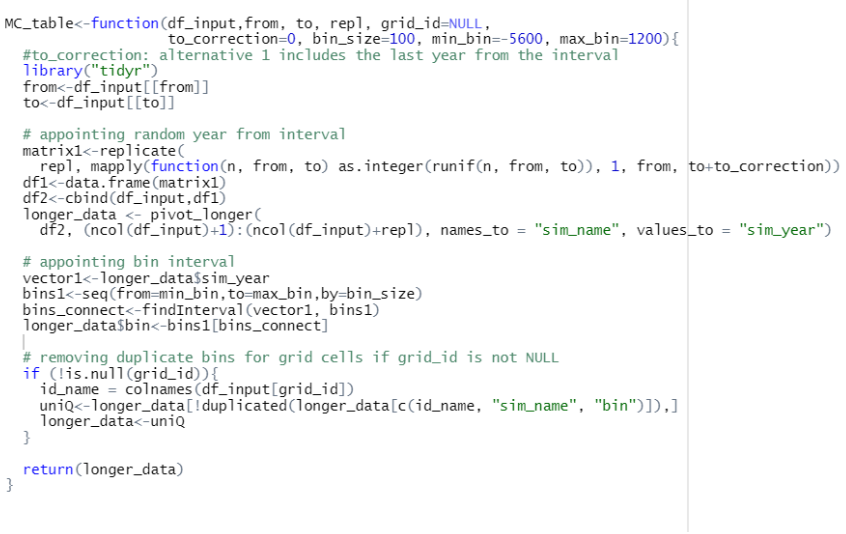
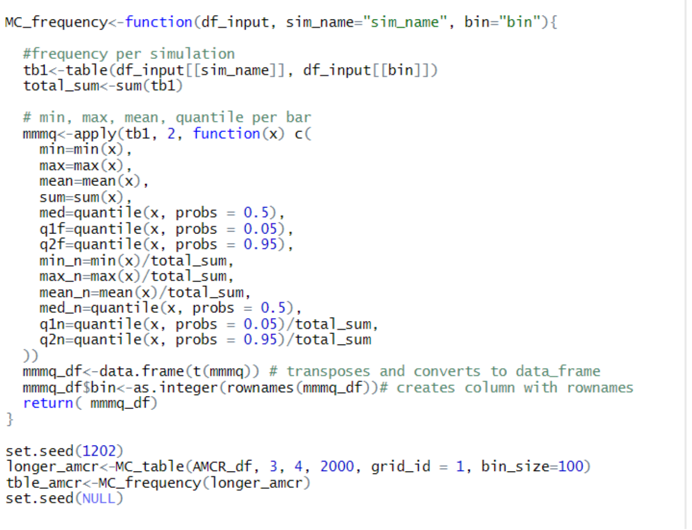
# 14. Appendix 1: R code

## Monte Carlo simulation function



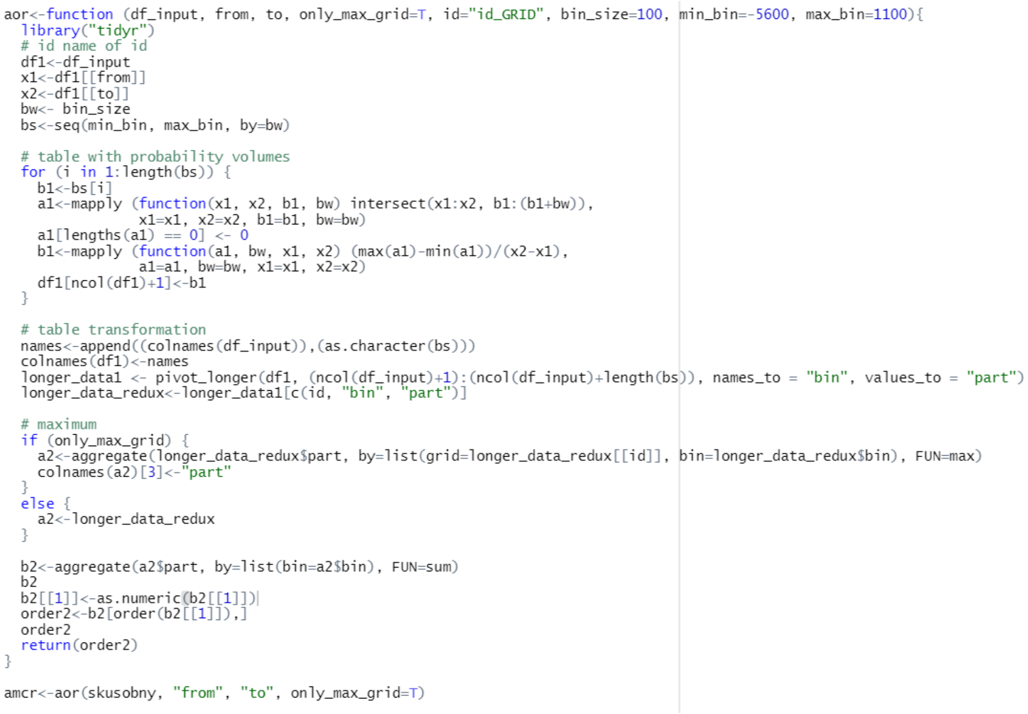
```r
MC_table<-function(df_input,from, to, repl, grid_id=NULL,
                   to_correction=0, bin_size=100, min_bin=-5600, max_bin=1200){
  #to_correction: alternative 1 includes the last year from the interval
  library("tidyr")
  from<-df_input[[from]]
  to<-df_input[[to]]

  # appointing random year from interval
  matrix1<-replicate(
    repl, mapply(function(n, from, to) as.integer(runif(n, from, to)), 1, from, to+to_correction))
  df1<-data.frame(matrix1)
  df2<-cbind(df_input,df1)
  longer_data <- pivot_longer(
    df2, (ncol(df_input)+1):(ncol(df_input)+repl), names_to = "sim_name", values_to = "sim_year")

  # appointing bin interval
  vector1<-longer_data$sim_year
  bins1<-seq(from=min_bin,to=max_bin,by=bin_size)
  bins_connect<-findInterval(vector1, bins1)
  longer_data$bin<-bins1[bins_connect]

  # removing duplicate bins for grid cells if grid_id is not NULL
  if (!is.null(grid_id)){
    id_name = colnames(df_input[grid_id])
    uniQ<-longer_data[!duplicated(longer_data[c(id_name, "sim_name", "bin")]),]
    longer_data<-uniQ
  }

  return(longer_data)
}
```

## Monte Carlo simulation function table and set up



```r
MC_frequency<-function(df_input, sim_name="sim_name", bin="bin"){

  #frequency per simulation
  tb1<-table(df_input[[sim_name]], df_input[[bin]])
  total_sum<-sum(tb1)

  # min, max, mean, quantile per bar
  mmmq<-apply(tb1, 2, function(x) c(
    min=min(x),
    max=max(x),
    mean=mean(x),
    sum=sum(x),
    med=quantile(x, probs = 0.5),
    q1f=quantile(x, probs = 0.05),
    q2f=quantile(x, probs = 0.95),
    min_n=min(x)/total_sum,
    max_n=max(x)/total_sum,
    mean_n=mean(x)/total_sum,
    med_n=quantile(x, probs = 0.5),
    q1n=quantile(x, probs = 0.05)/total_sum,
    q2n=quantile(x, probs = 0.95)/total_sum
  ))
  mmmq_df<-data.frame(t(mmmq)) # transposes and converts to data_frame
  mmmq_df$bin<-as.integer(rownames(mmmq_df))# creates column with rownames
  return( mmmq_df)
}

set.seed(1202)
longer_amcr<-MC_table(AMCR_df, 3, 4, 2000, grid_id = 1, bin_size=100)
tble_amcr<-MC_frequency(longer_amcr)
set.seed(NULL)
```

# Aoristic analysis function and set up

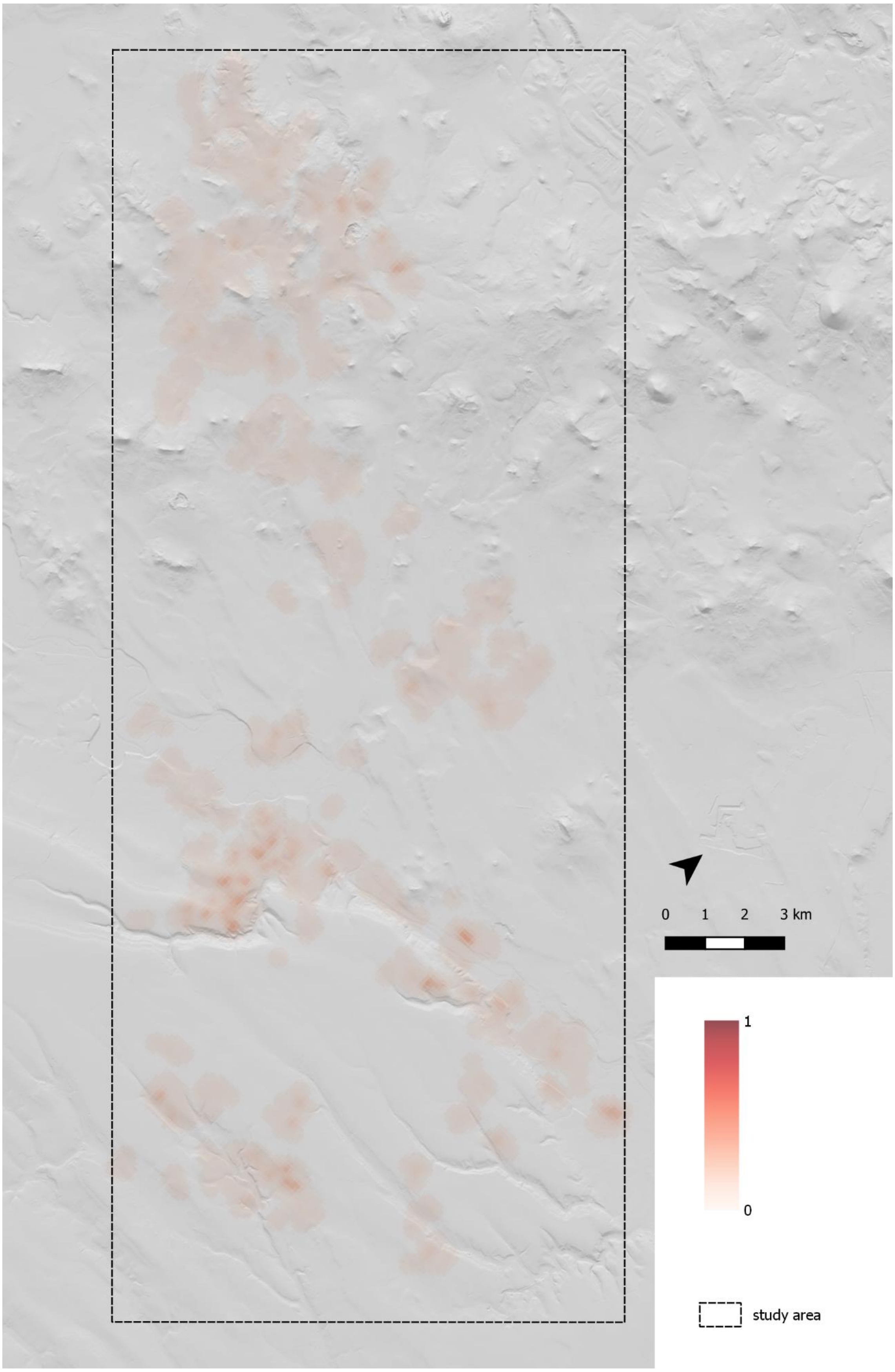


```r
aor<-function (df_input, from, to, only_max_grid=T, id="id_GRID", bin_size=100, min_bin=-5600, max_bin=1100){
  library("tidyr")
  # id name of id
  df1<-df_input
  x1<-df1[[from]]
  x2<-df1[[to]]
  bw<- bin_size
  bs<-seq(min_bin, max_bin, by=bw)

  # table with probability volumes
  for (i in 1:length(bs)) {
    b1<-bs[i]
    a1<-mapply (function(x1, x2, b1, bw) intersect(x1:x2, b1:(b1+bw)),
                x1=x1, x2=x2, b1=b1, bw=bw)
    a1[lengths(a1) == 0] <- 0
    b1<-mapply (function(a1, bw, x1, x2) (max(a1)-min(a1))/(x2-x1),
                a1=a1, bw=bw, x1=x1, x2=x2)
    df1[ncol(df1)+1]<-b1
  }

  # table transformation
  names<-append((colnames(df_input)),(as.character(bs)))
  colnames(df1)<-names
  longer_data1 <- pivot_longer(df1, (ncol(df_input)+1):(ncol(df_input)+length(bs)), names_to = "bin", values_to = "part")
  longer_data_redux<-longer_data1[c(id, "bin", "part")]

  # maximum
  if (only_max_grid) {
    a2<-aggregate(longer_data_redux$part, by=list(grid=longer_data_redux[[id]], bin=longer_data_redux$bin), FUN=max)
    colnames(a2)[3]<-"part"
  }
  else {
    a2<-longer_data_redux
  }

  b2<-aggregate(a2$part, by=list(bin=a2$bin), FUN=sum)
  b2
  b2[[1]]<-as.numeric(b2[[1]])
  order2<-b2[order(b2[[1]]),]
  order2
  return(order2)
}

amcr<-aor(skusobny, "from", "to", only_max_grid=T)
```

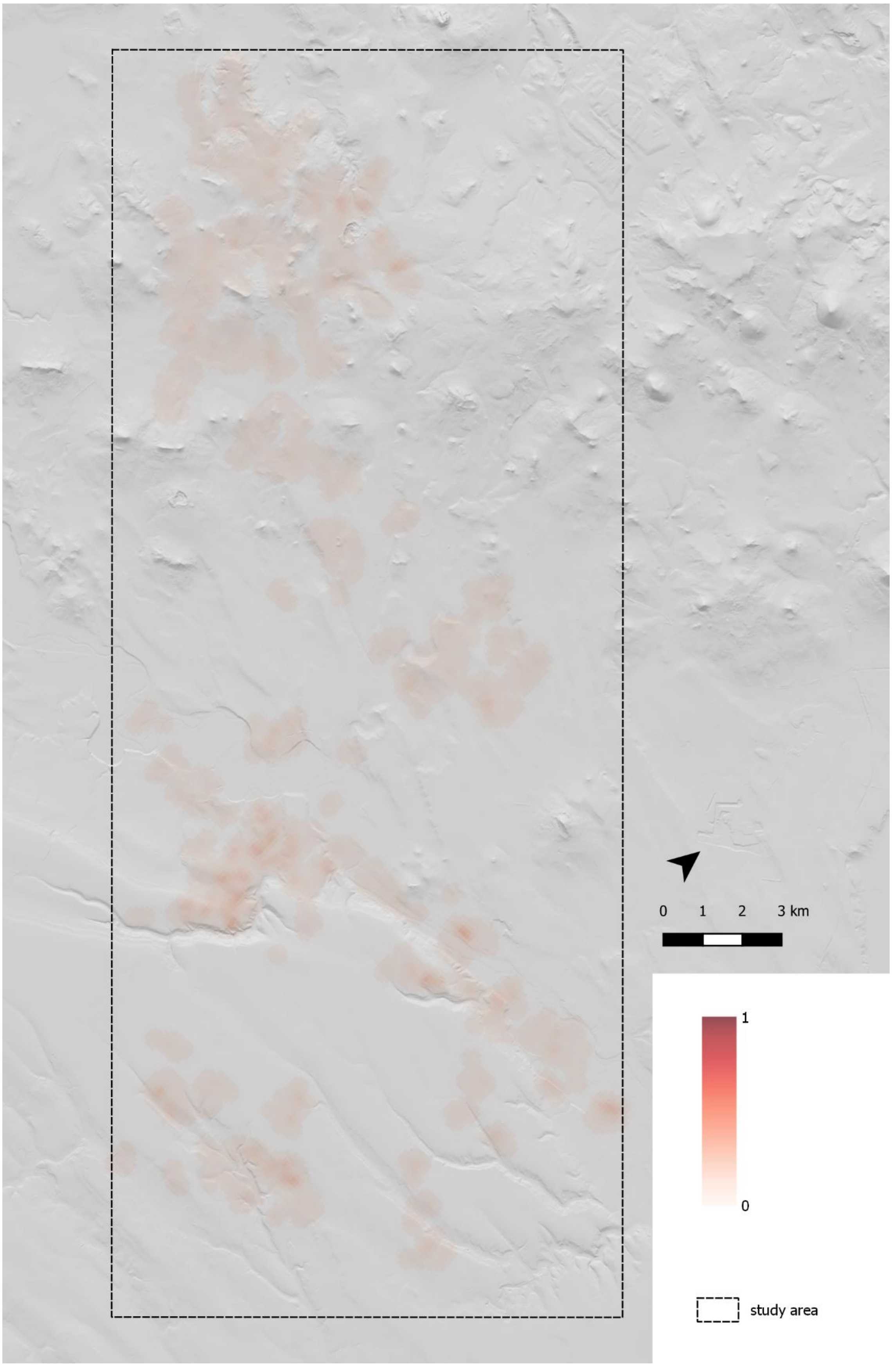
# 15. Appendix 2: Maps of aoristic weights assigned to 400-years time intervals.

Results filtered by Gaussian filter. Basemap DMR 5G (ČÚZK a [online]).

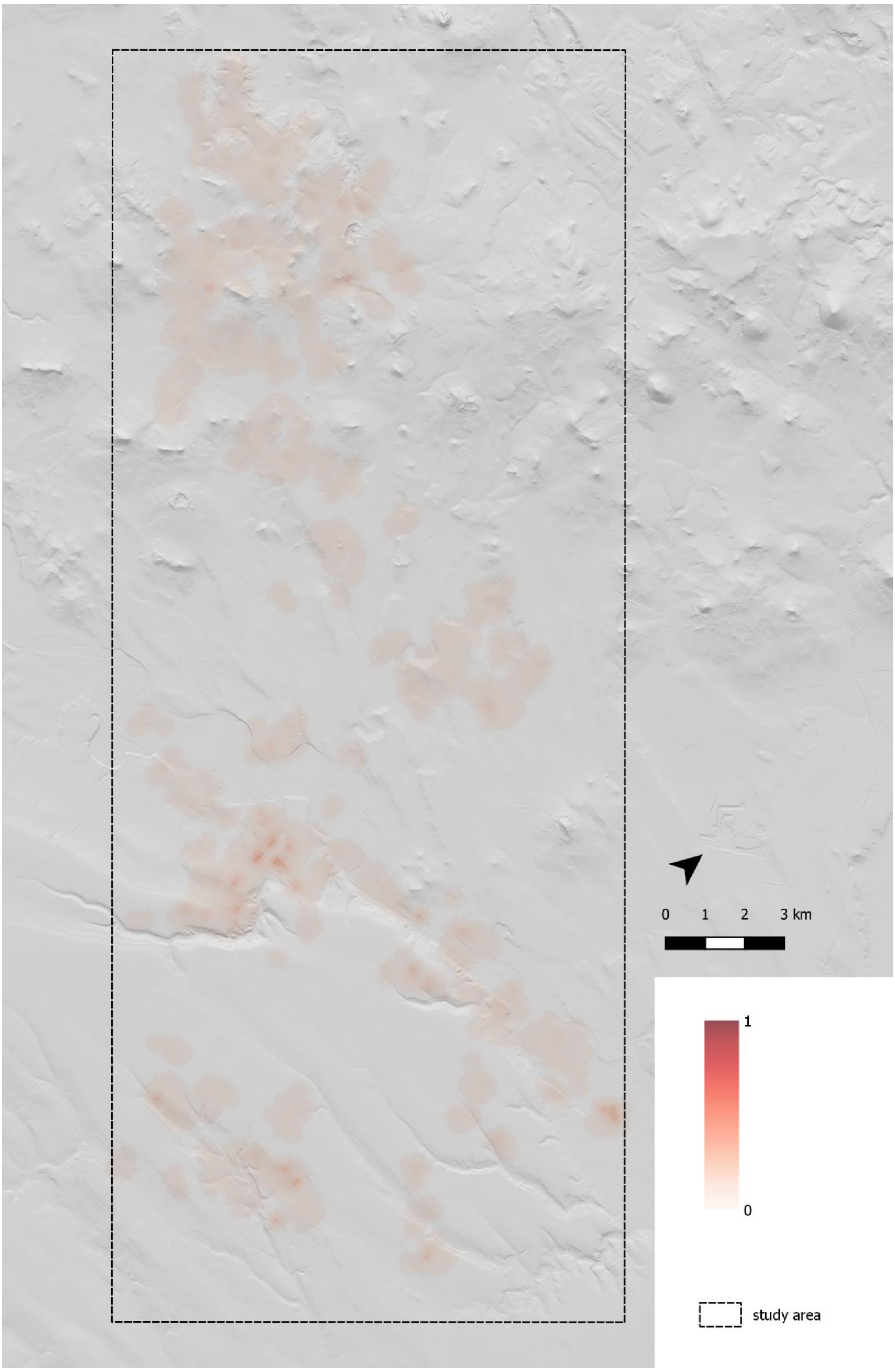
ALRNB 5600 BC – 5200 BC



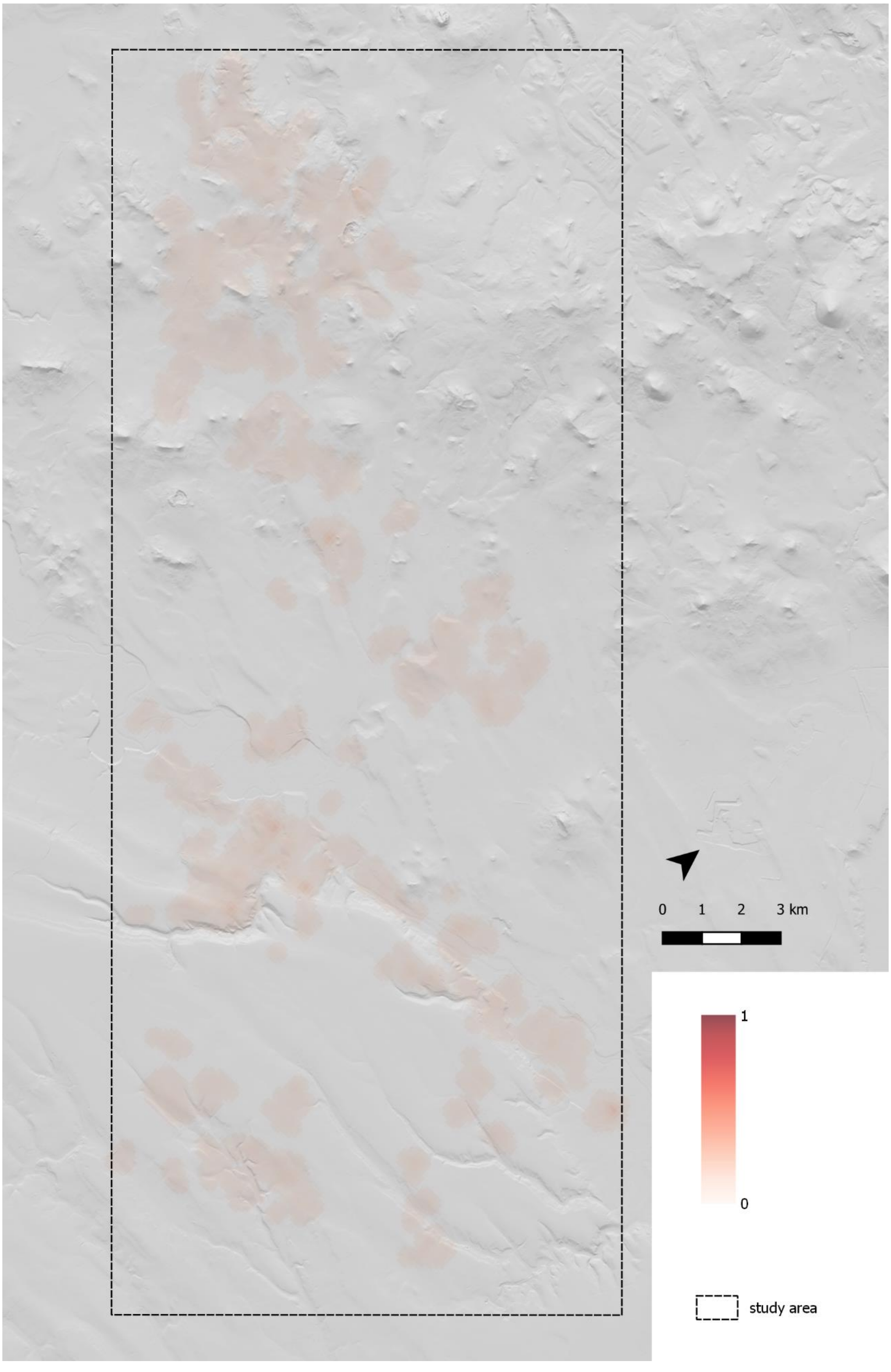
ALRNB 5200 BC – 4800 BC



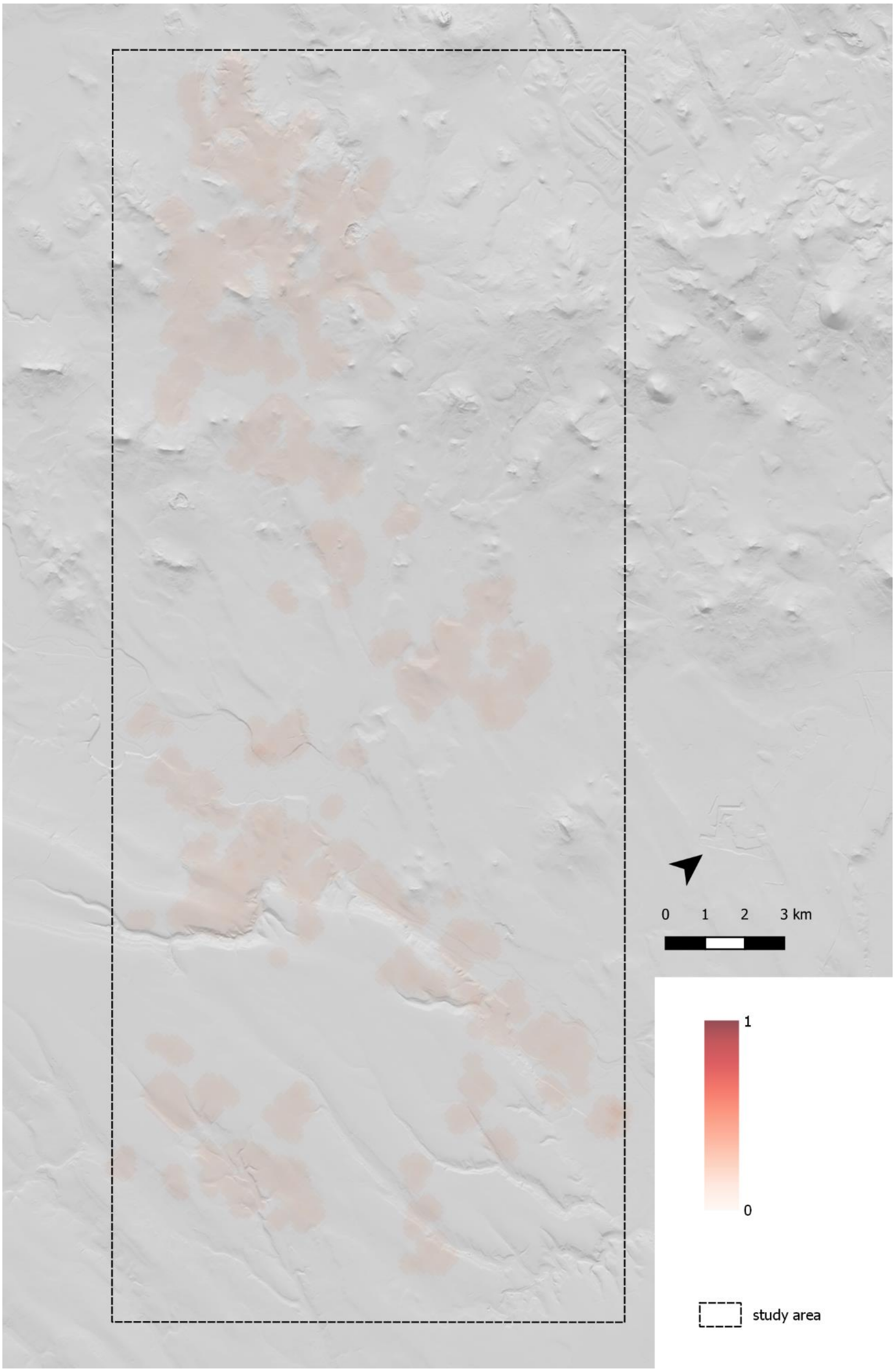
ALRNB 4800 BC – 4400 BC



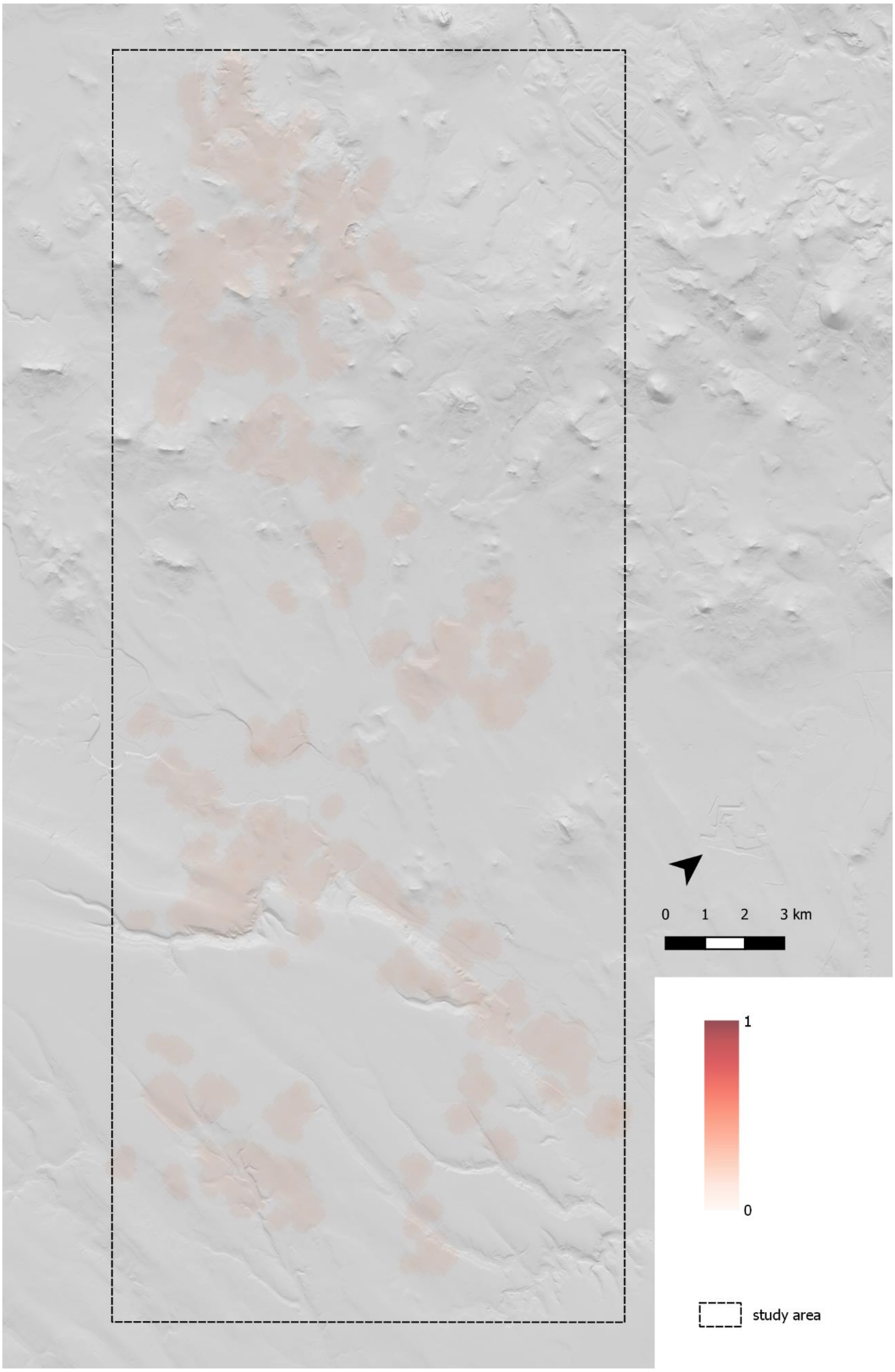
ALRNB 4400 BC – 4000 BC



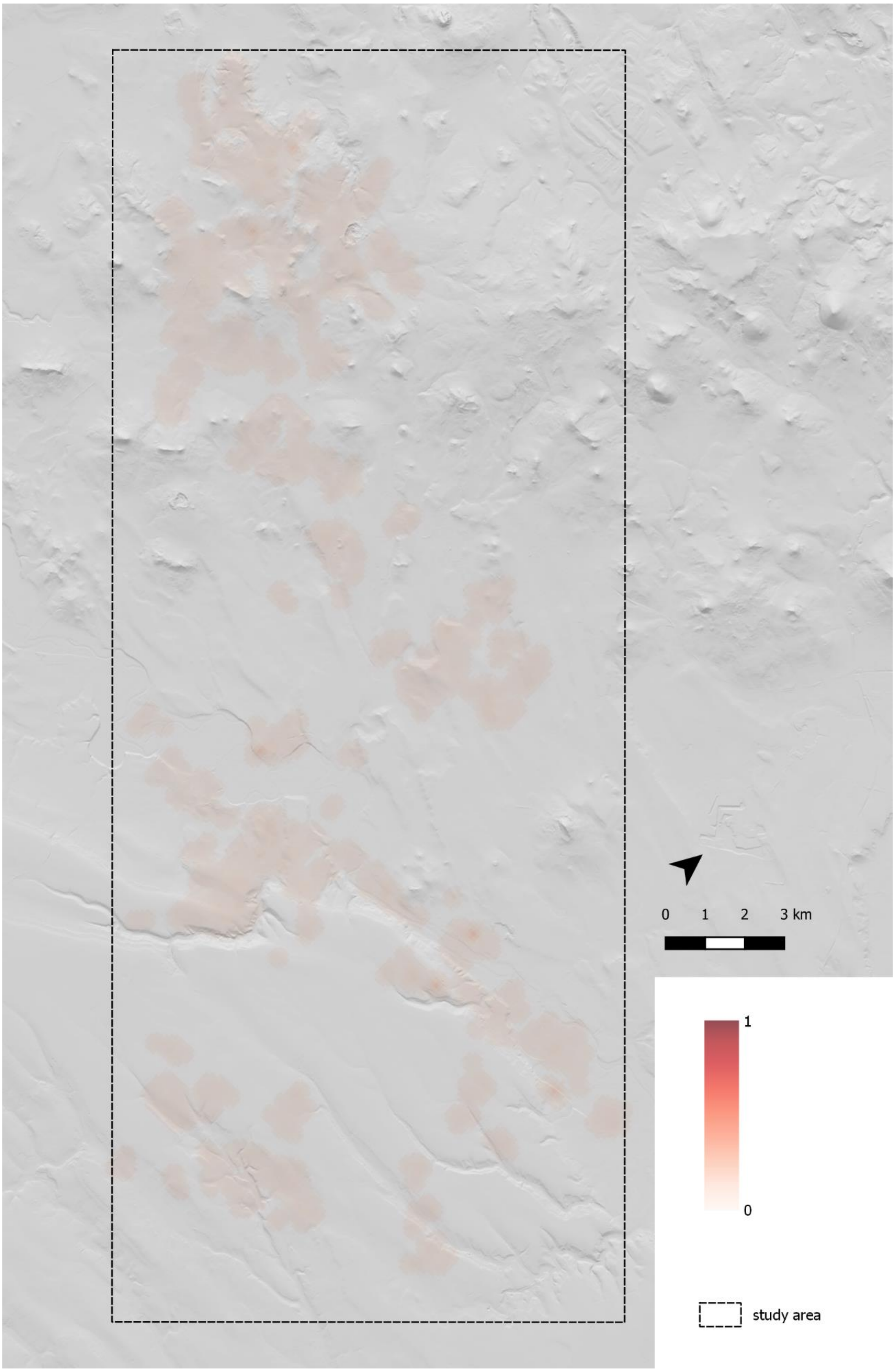
ALRNB 4000 BC – 3600 BC



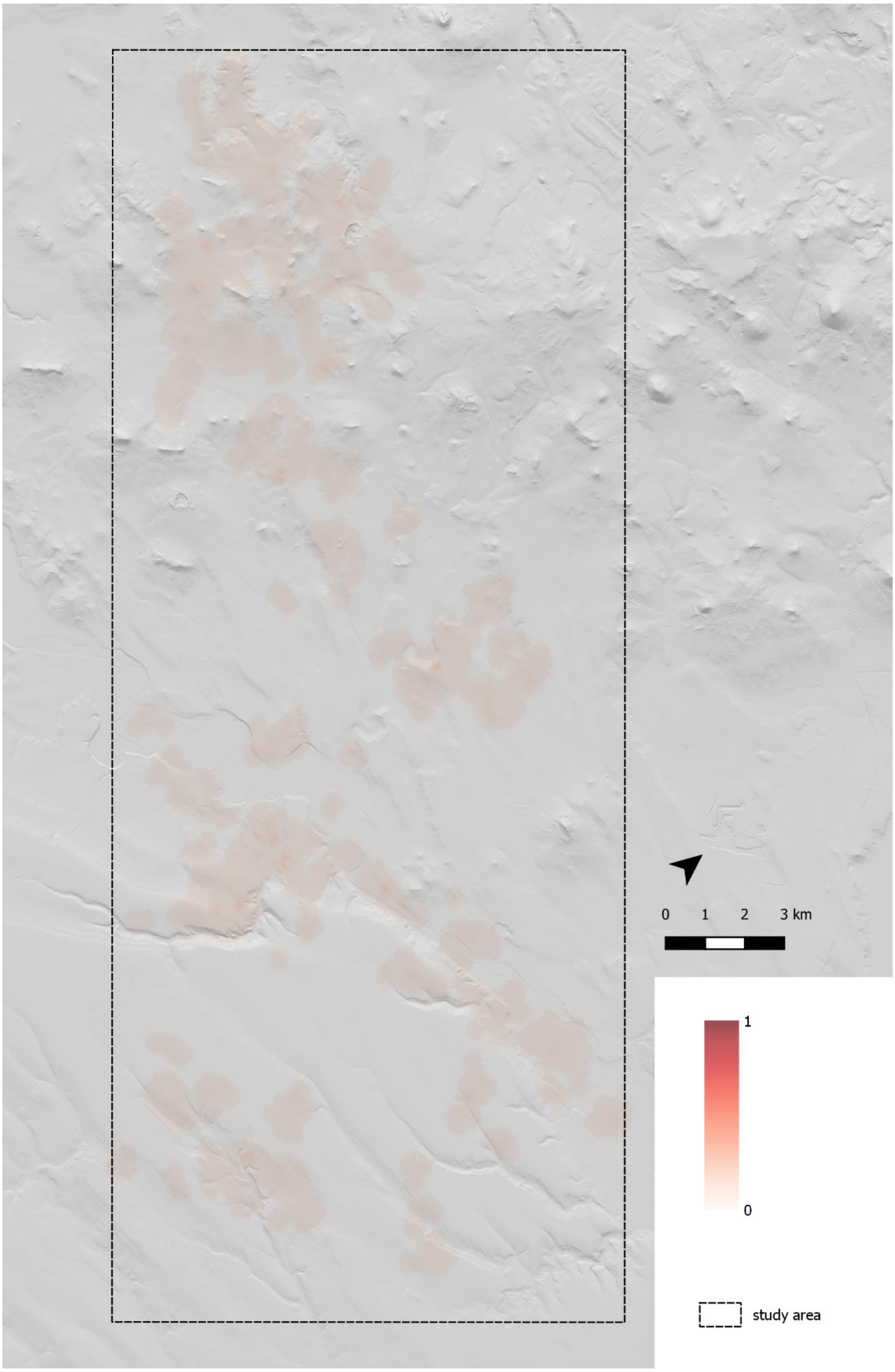
ALRNB 3600 BC – 3200 BC



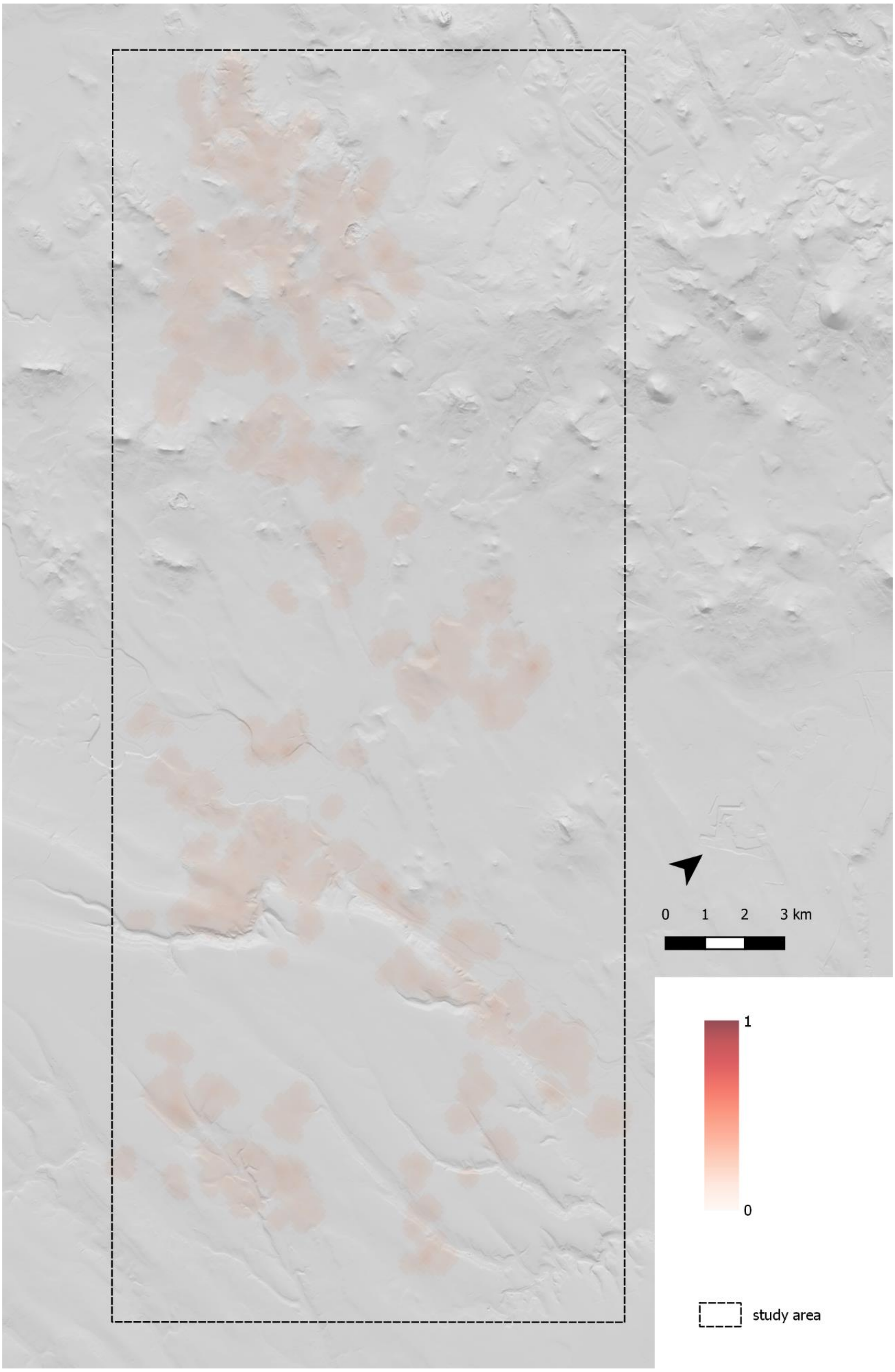
ALRNB 3200 BC – 2800 BC



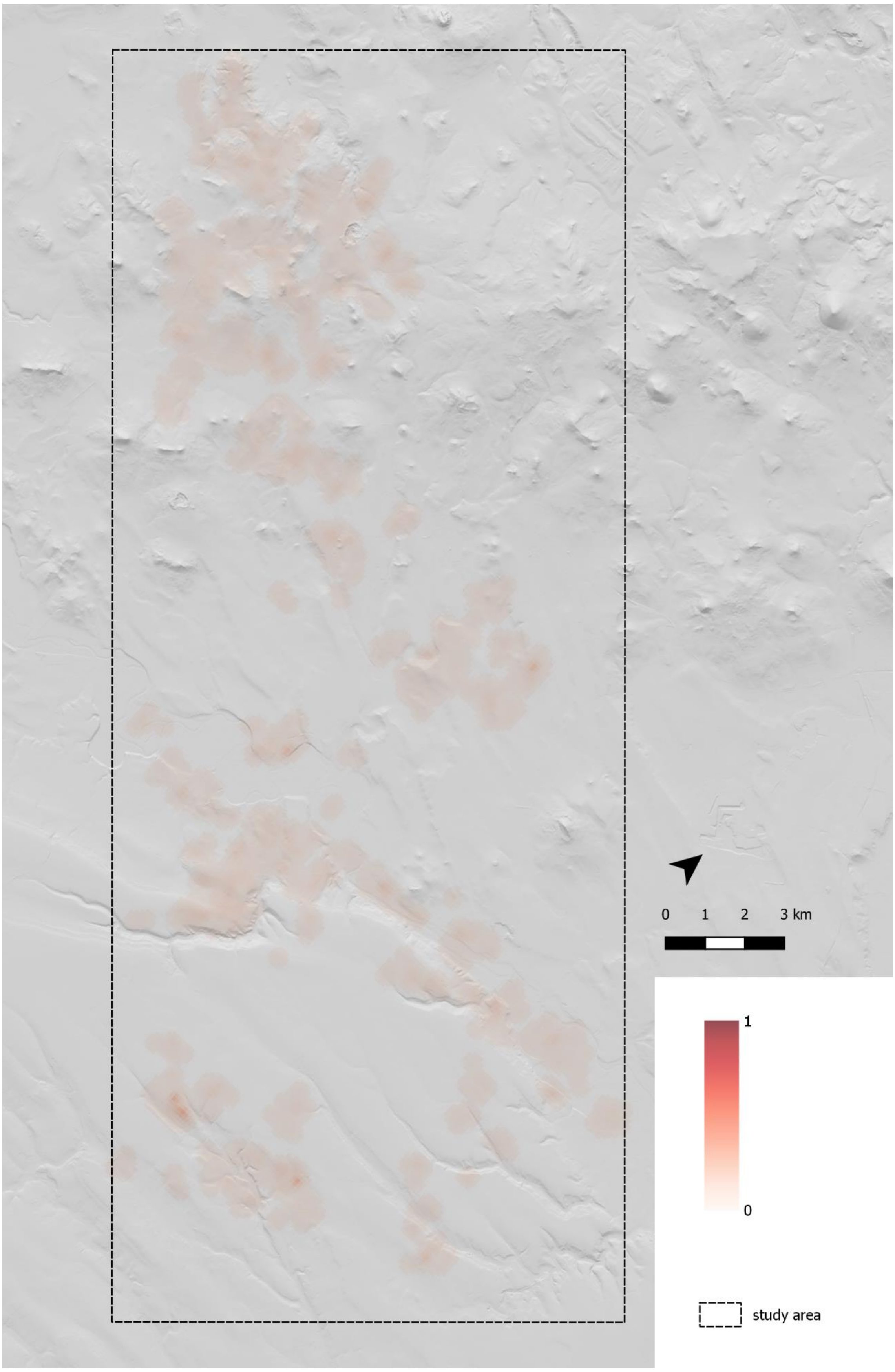
ALRNB 2800 BC – 2400 BC



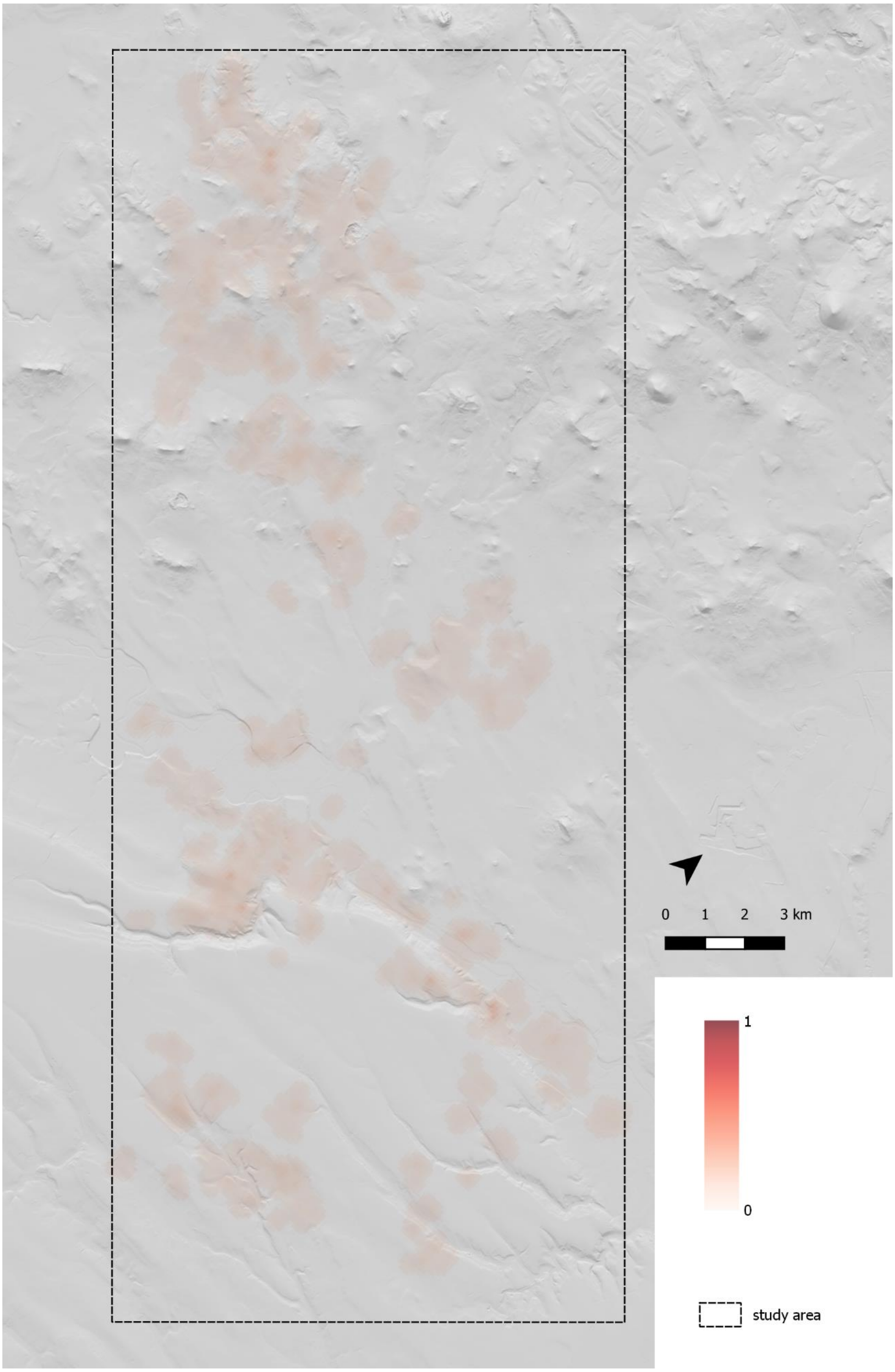
ALRNB 2400 BC – 2000 BC



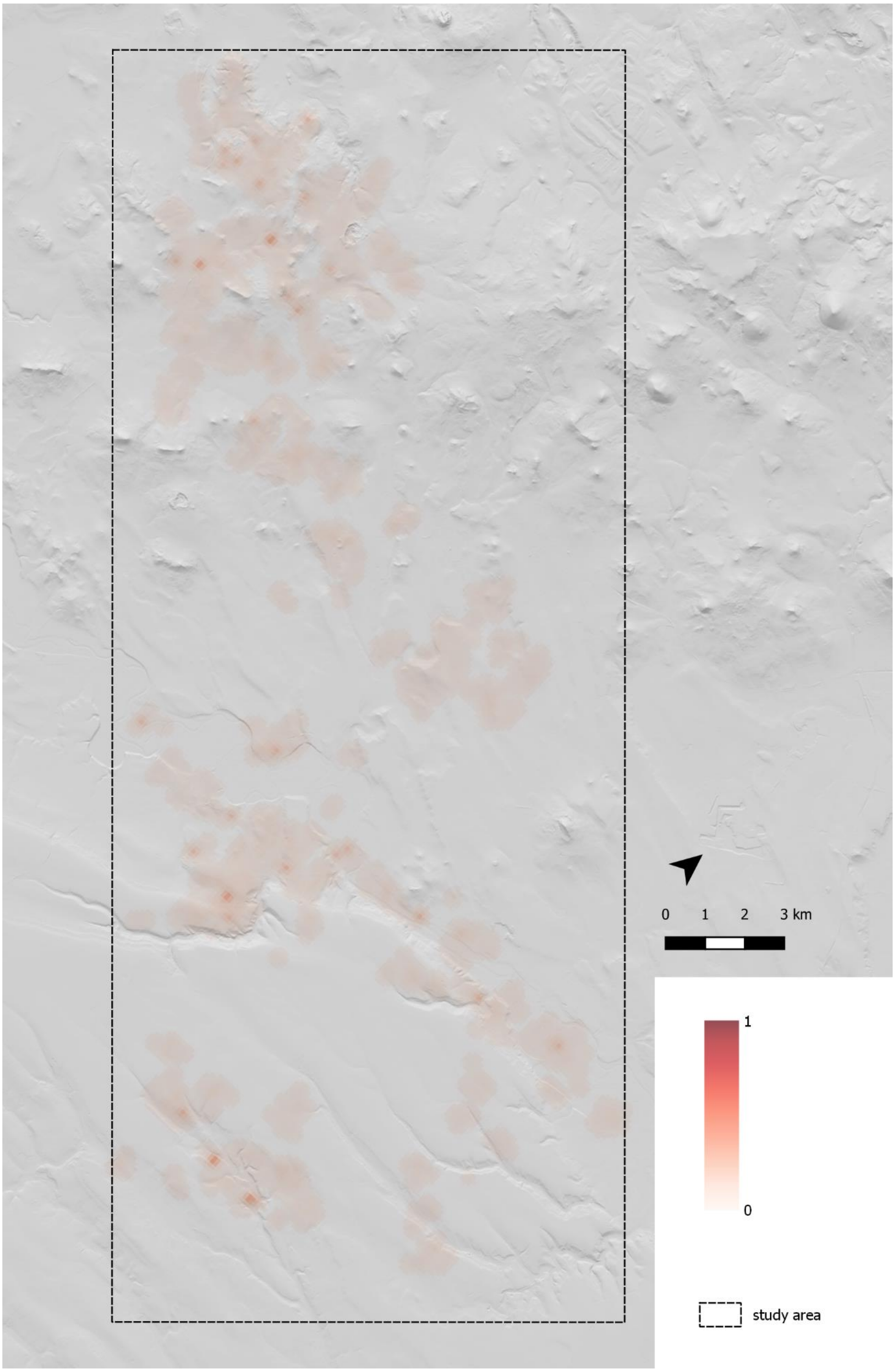
ALRNB 2000 BC – 1600 BC



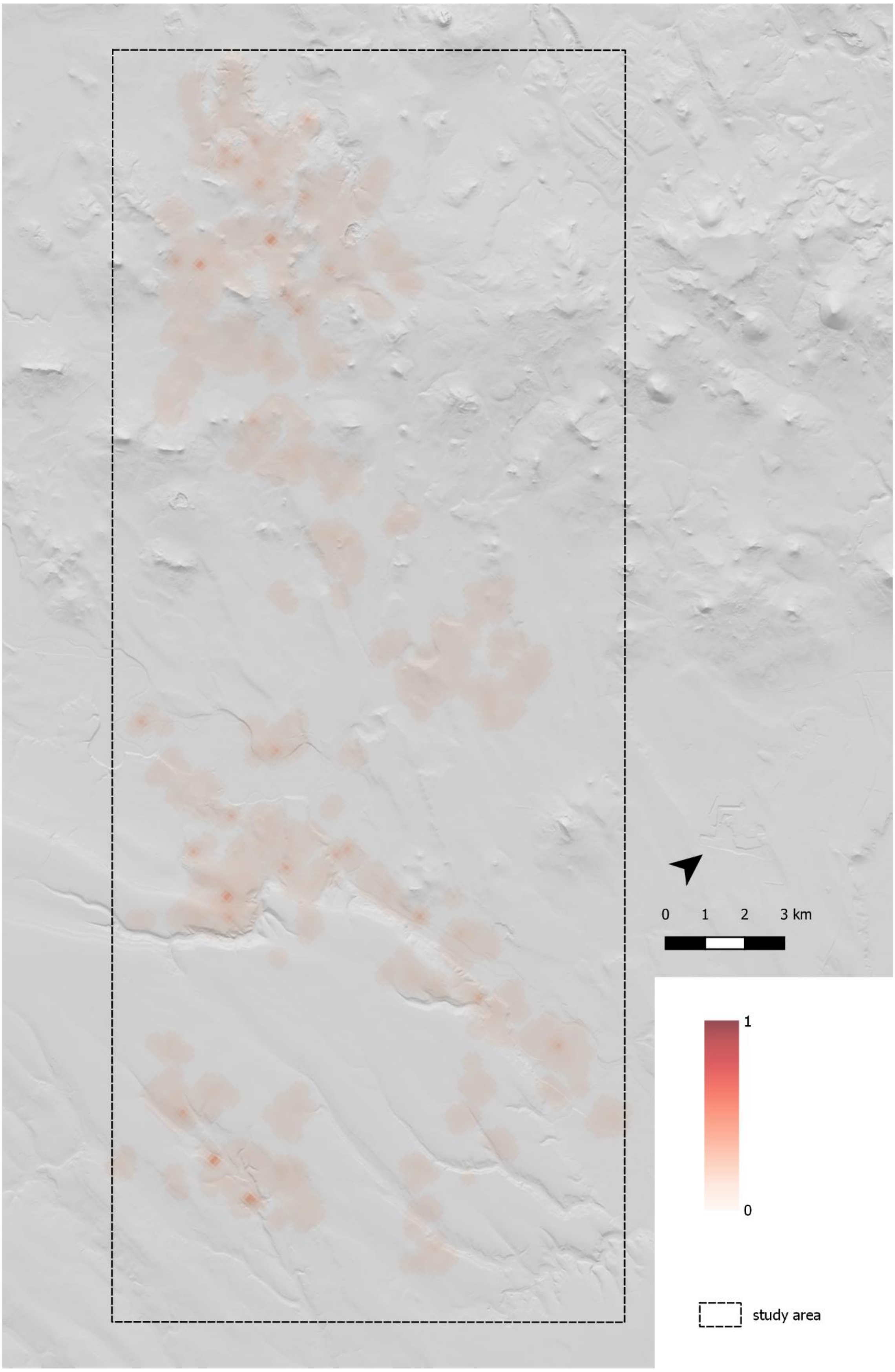
ALRNB 1600 BC – 1200 BC



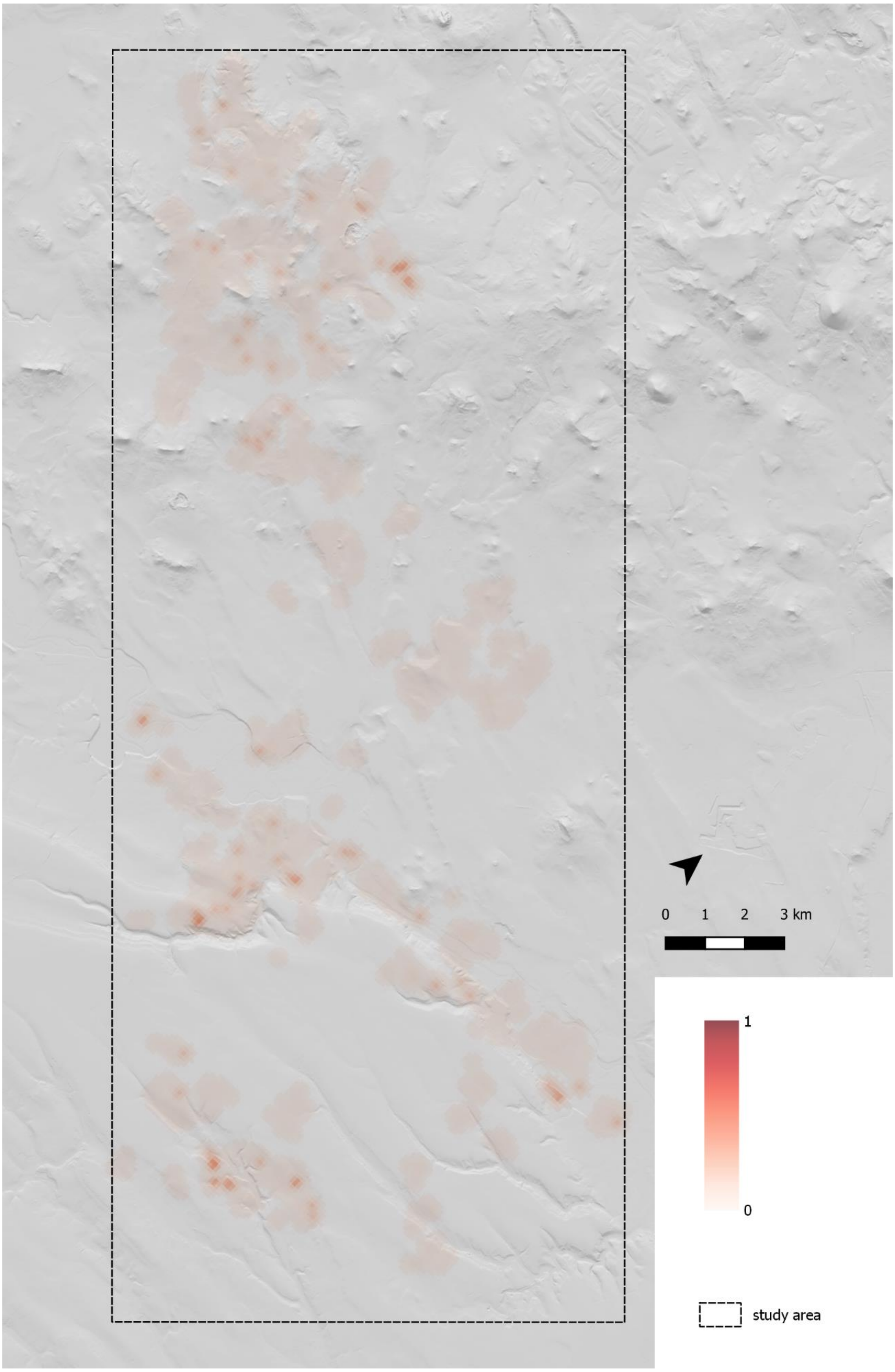
ALRNB 1200 BC – 800 BC



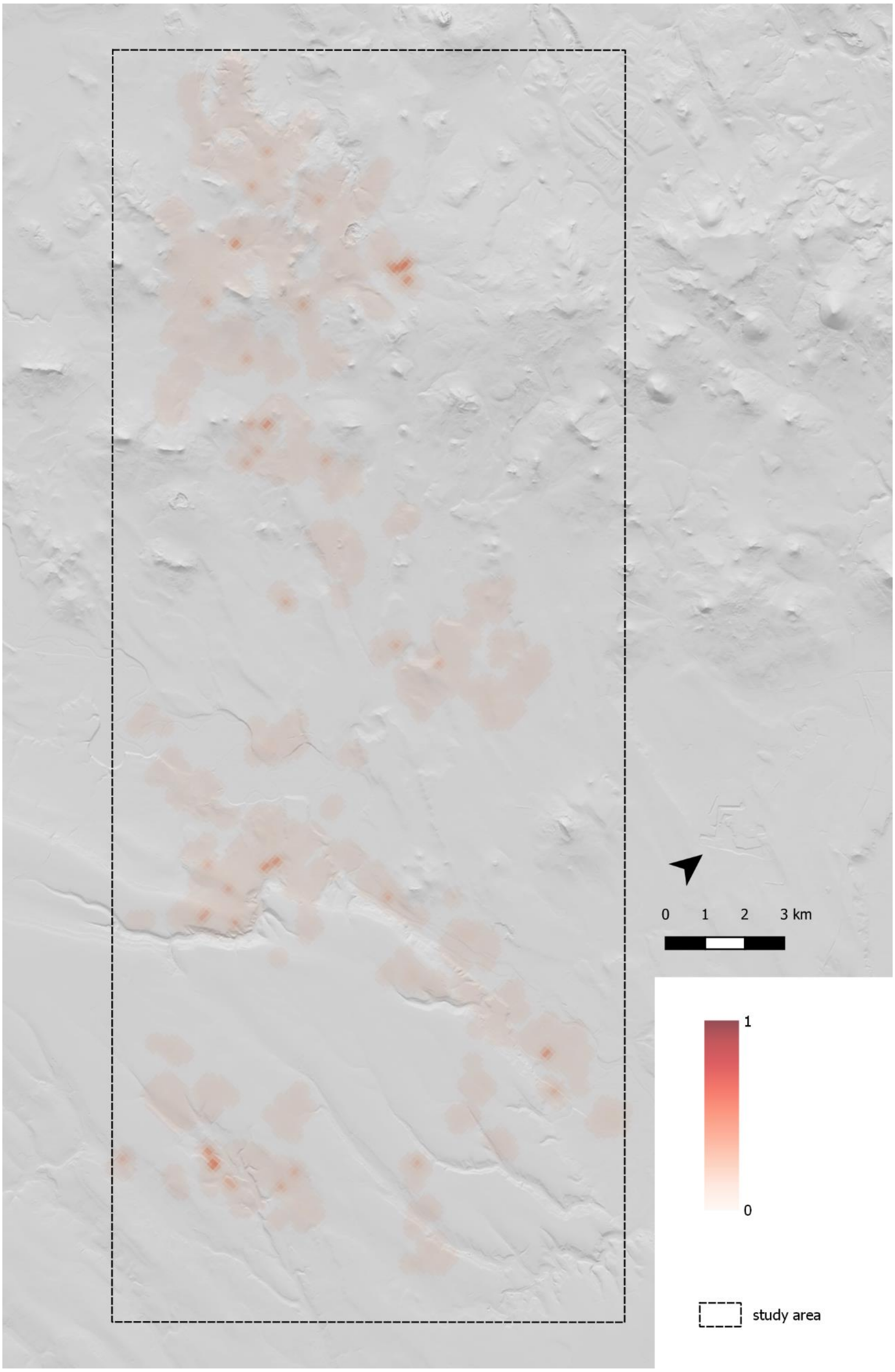
ALRNB 800 BC – 400 BC



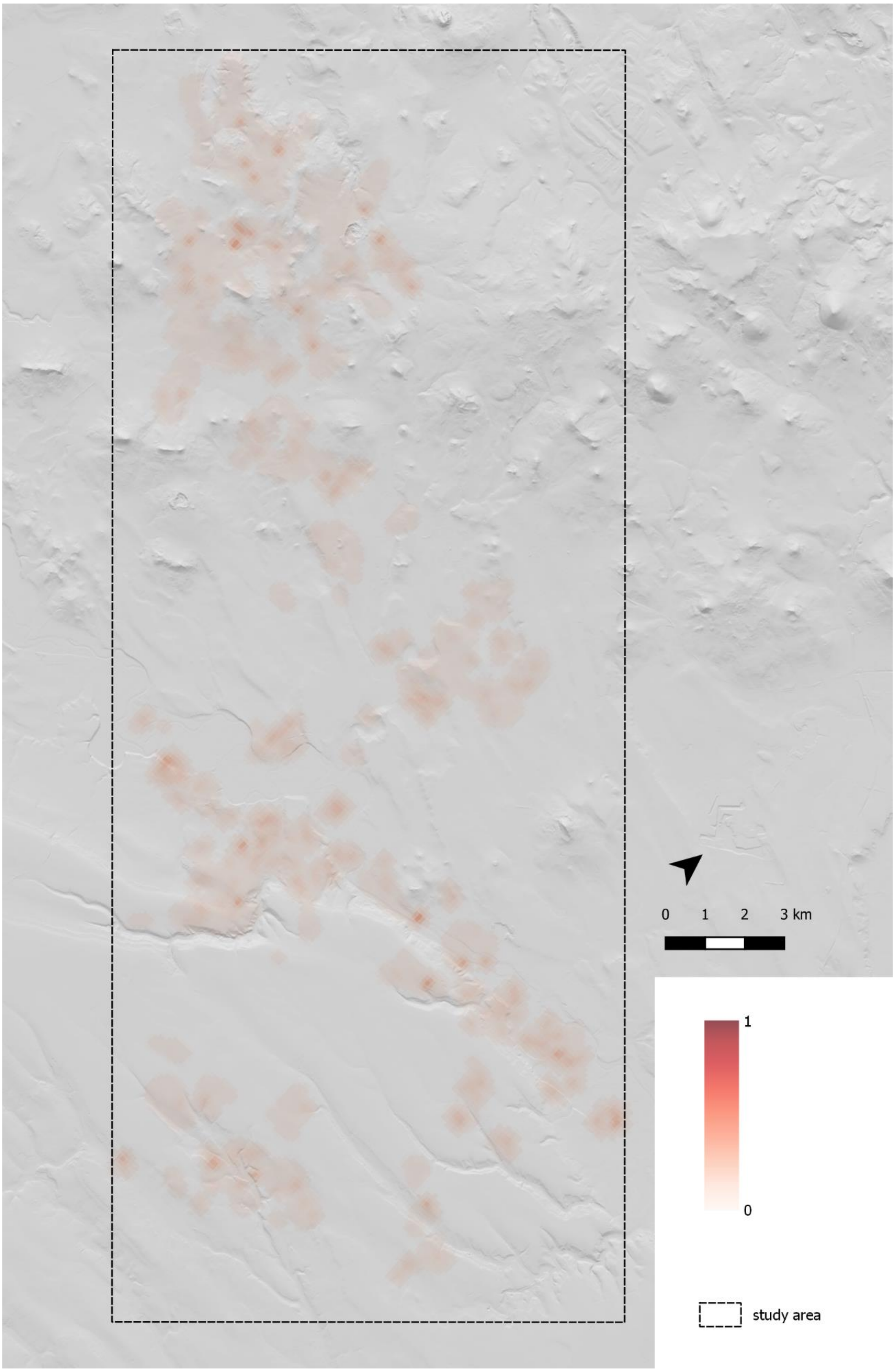
ALRNB 400 BC – 0



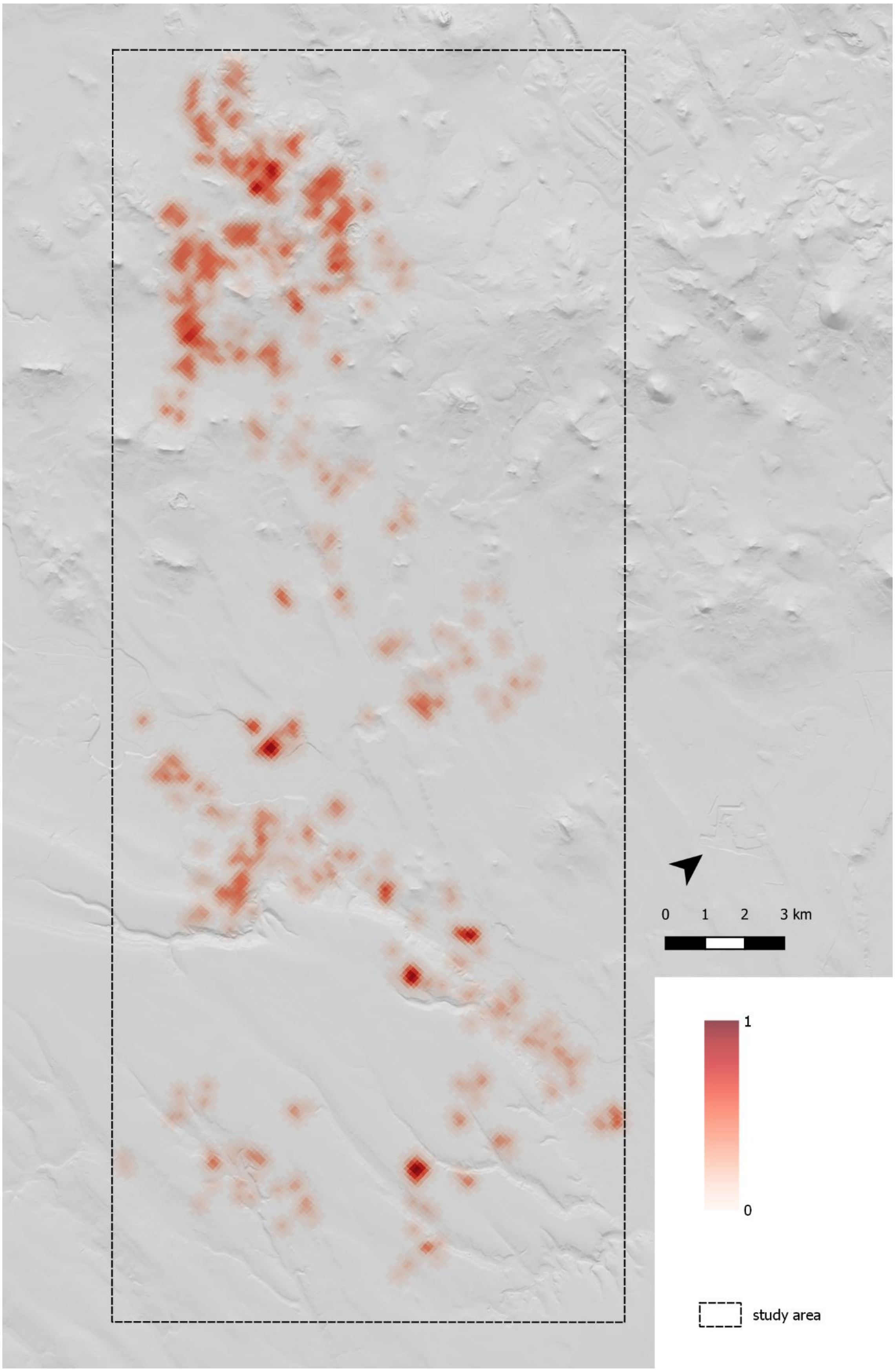
ALRNB 0 – 400 AD



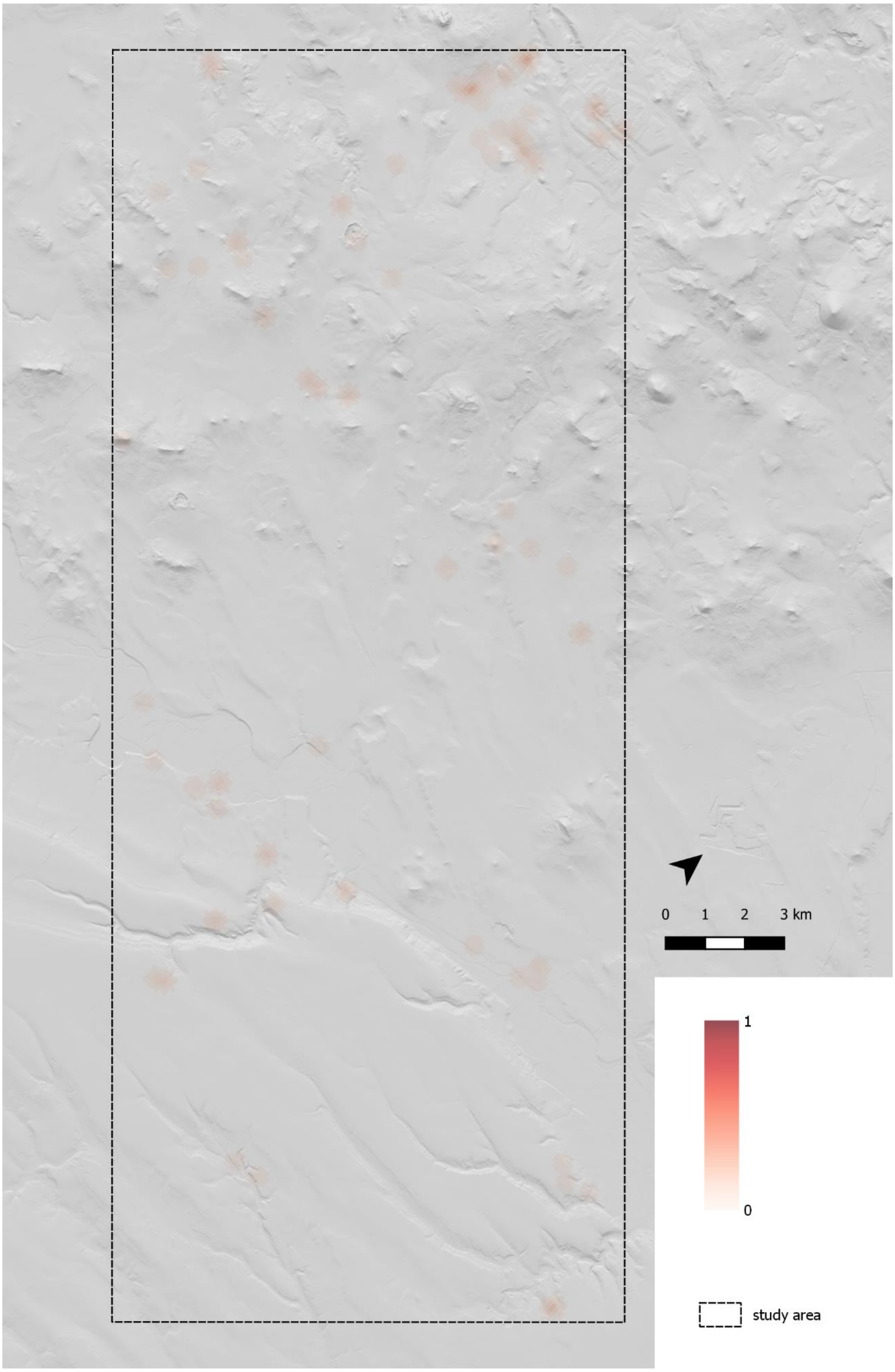
ALRNB 400 AD – 800 AD



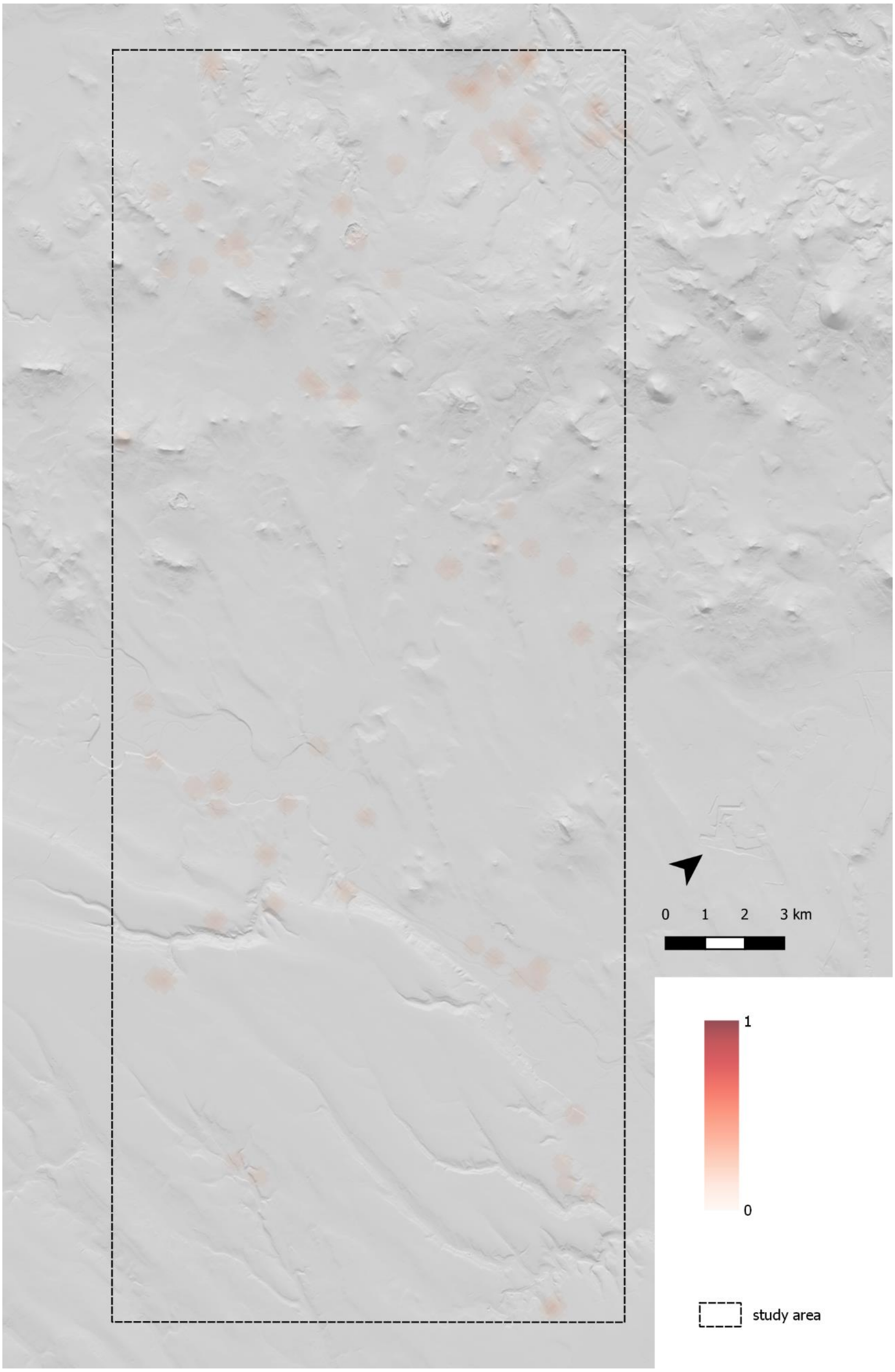
ALRNB 800 AD - 1200 AD



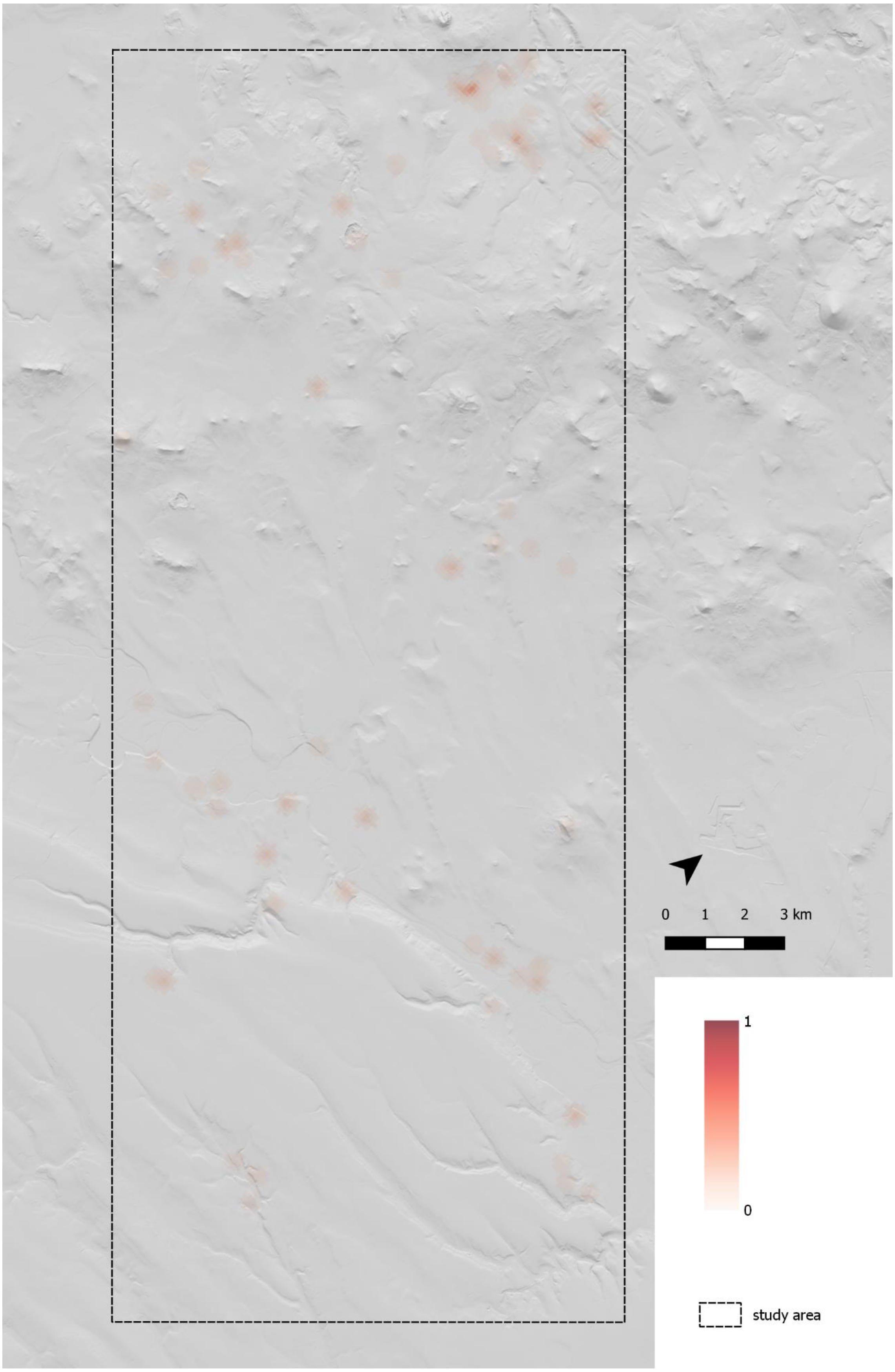
AMČR 5600 BC – 5200 BC



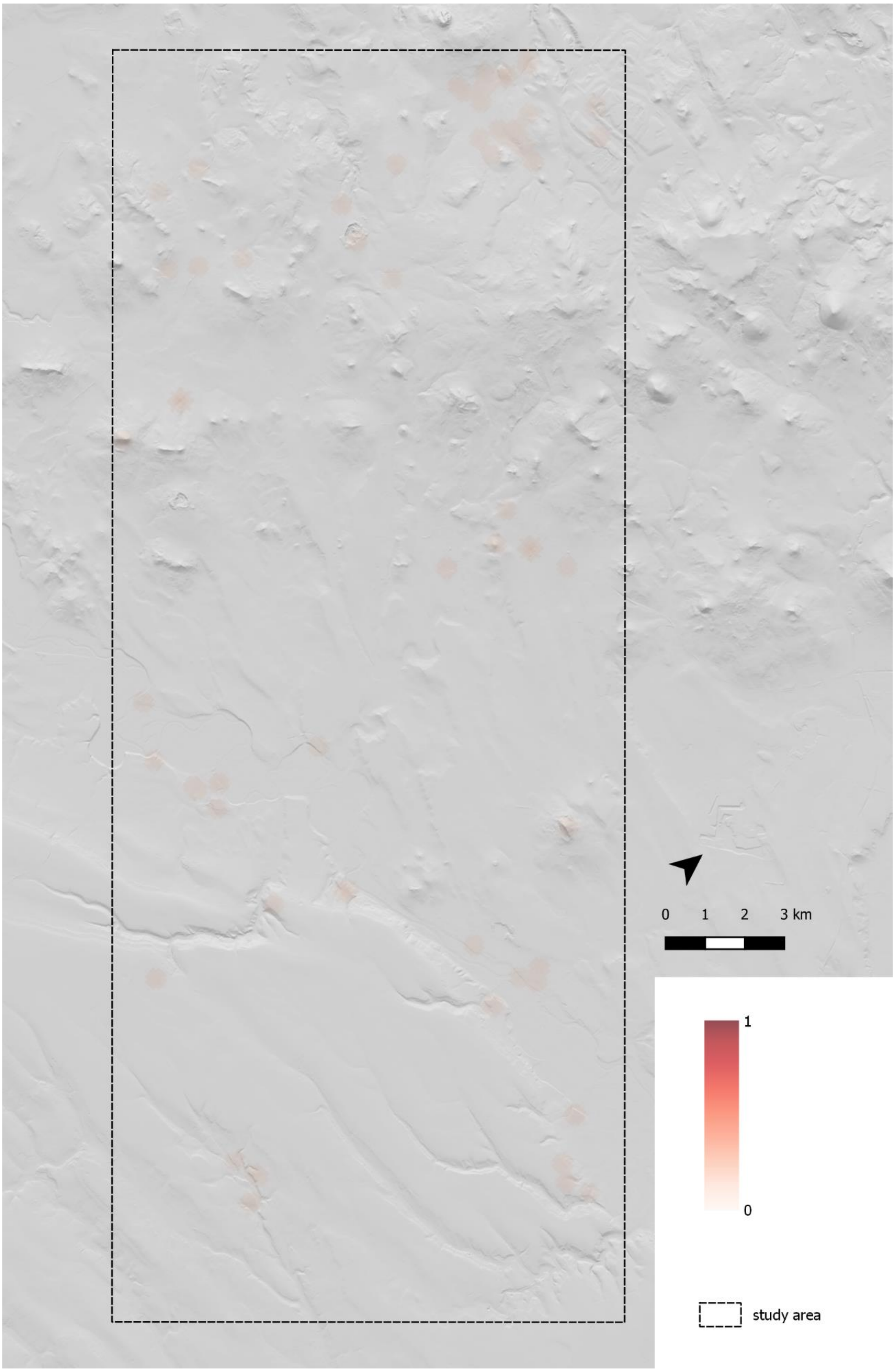
AMČR 5200 BC – 4800 BC



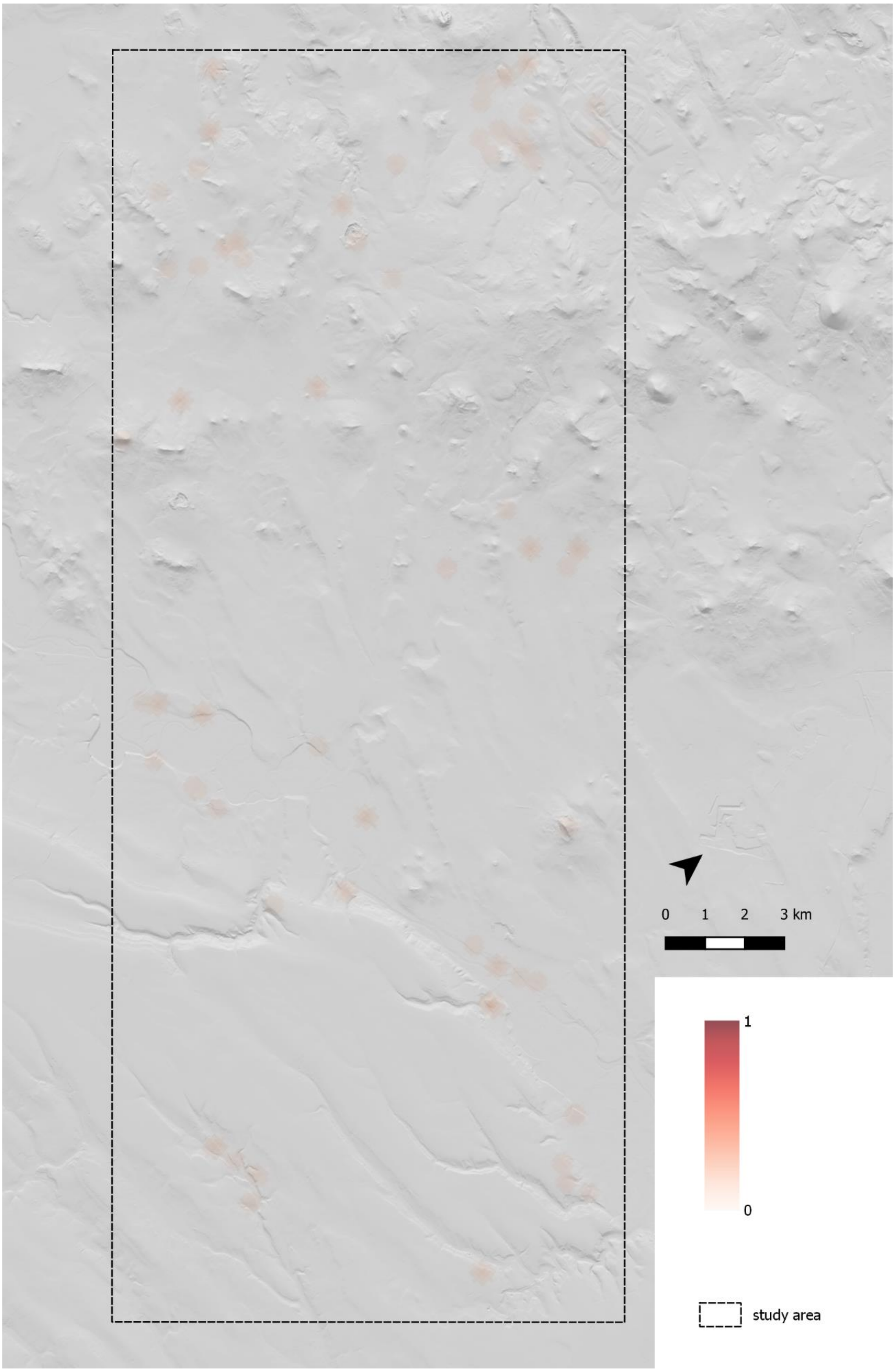
AMČR 4800 BC – 4400 BC



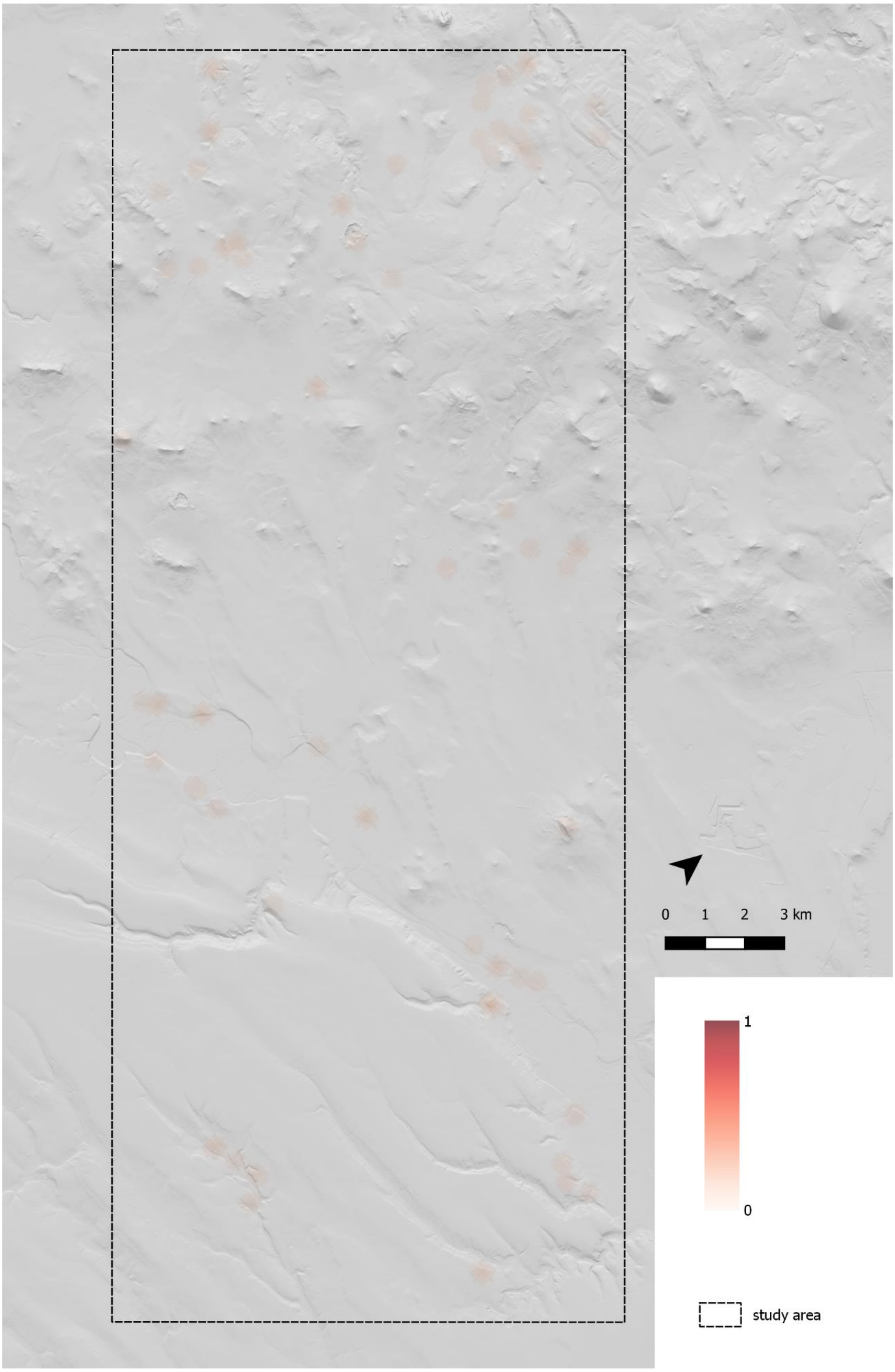
AMČR 4400 BC – 4000 BC



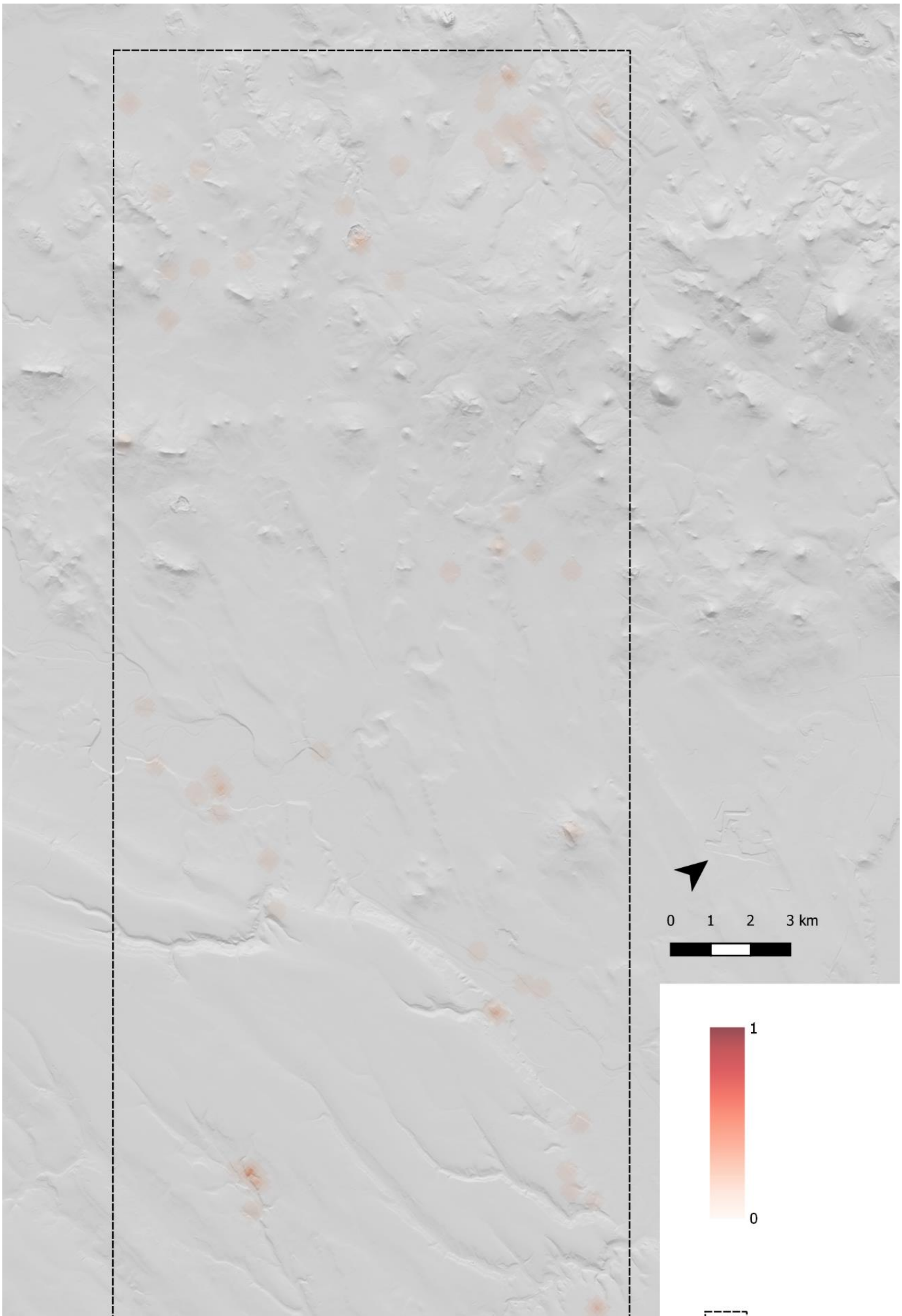
AMČR 4000 BC – 3600 BC



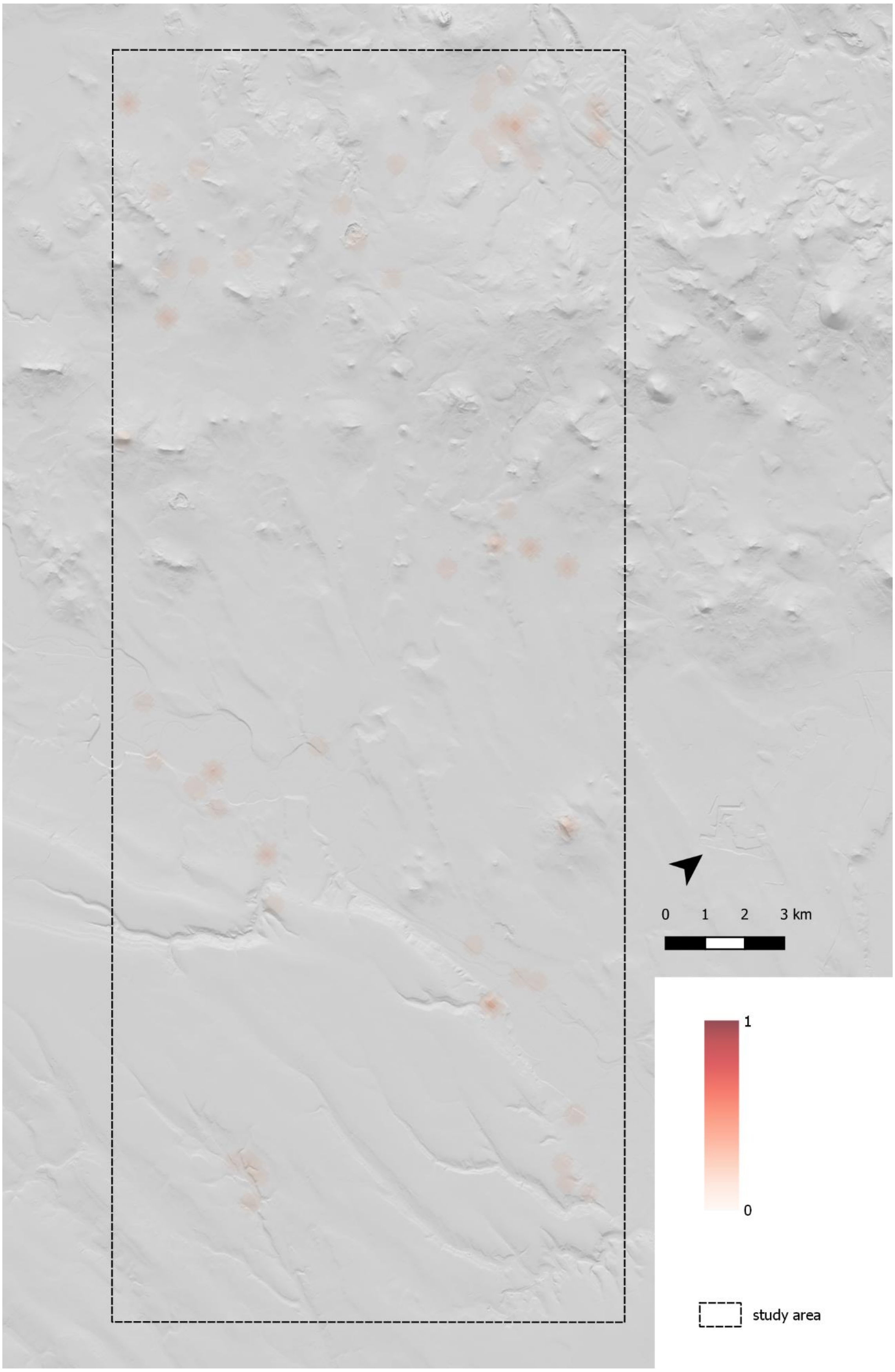
AMČR 3600 BC – 3200 BC



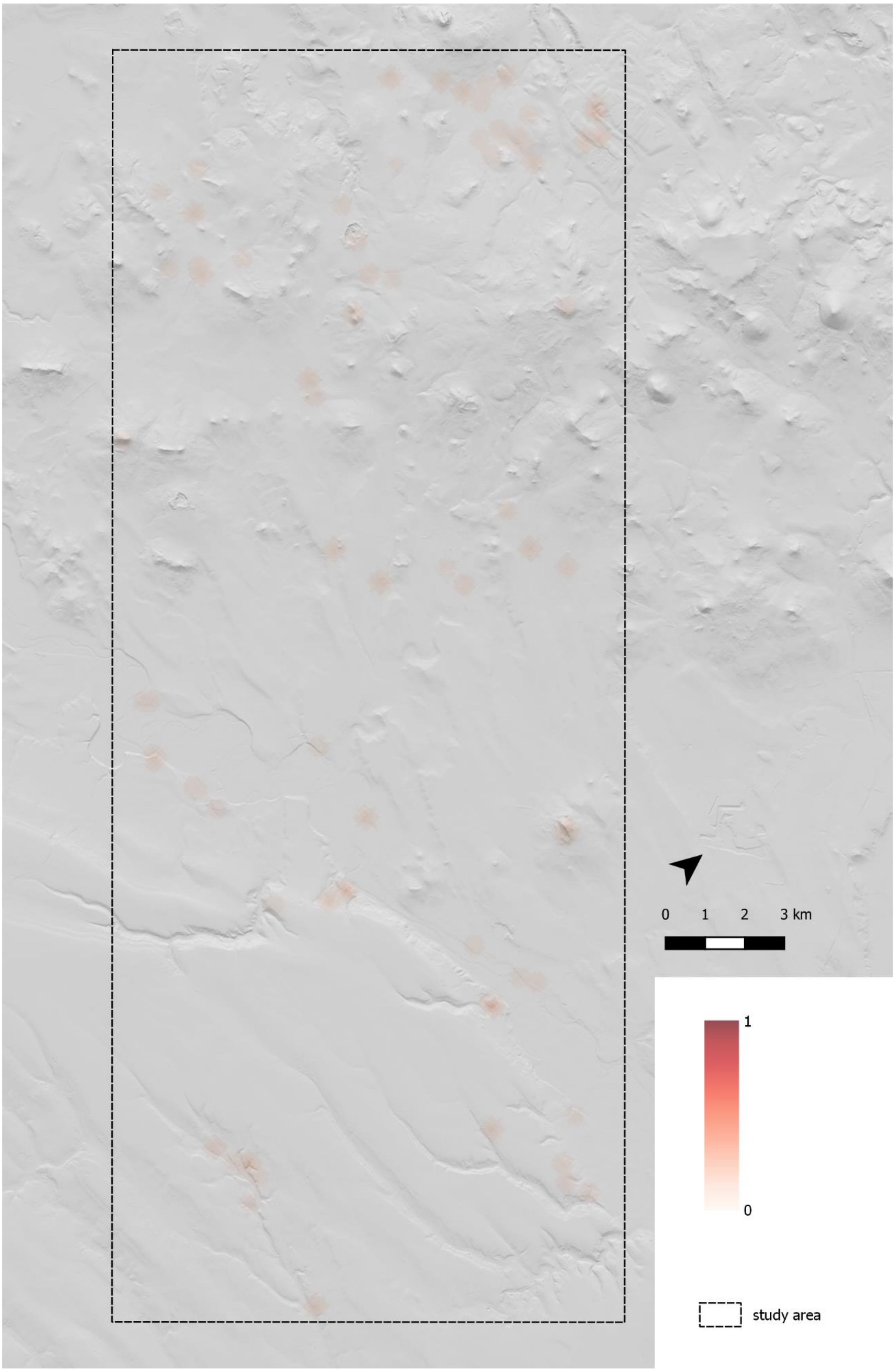
AMČR 3200 BC – 2800 BC



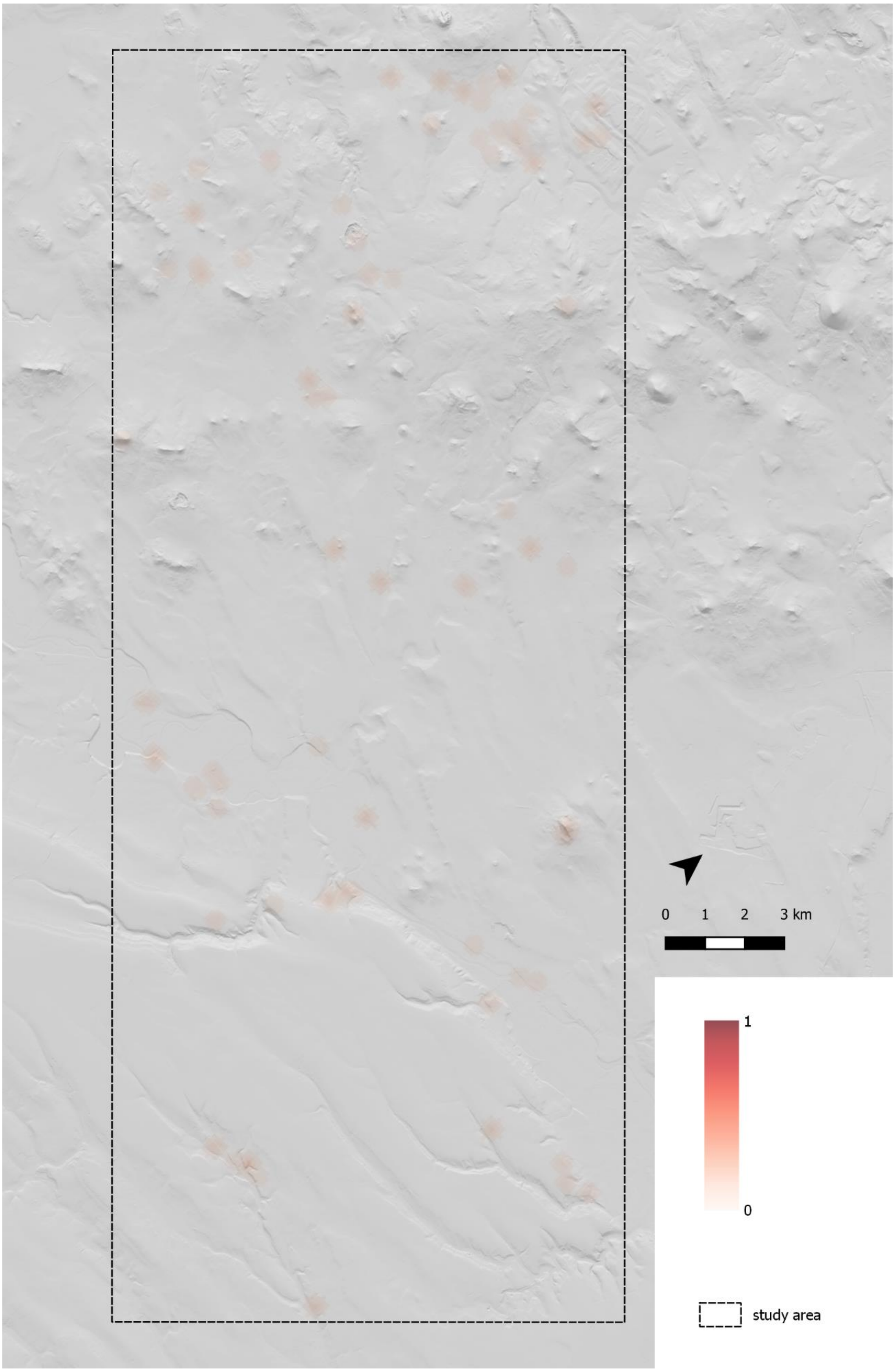
AMČR 2800 BC – 2400 BC



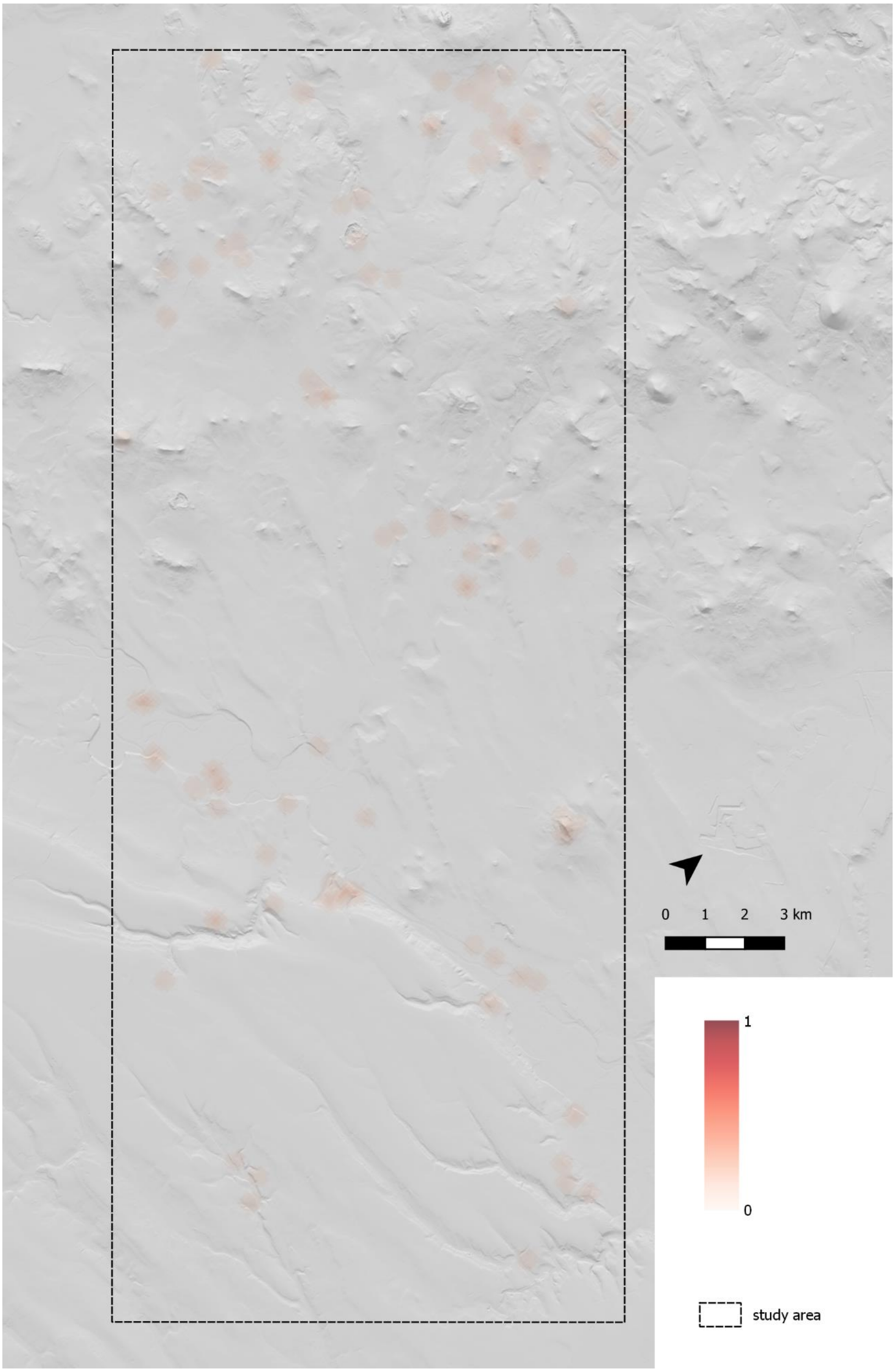
AMČR 2400 BC – 2000 BC



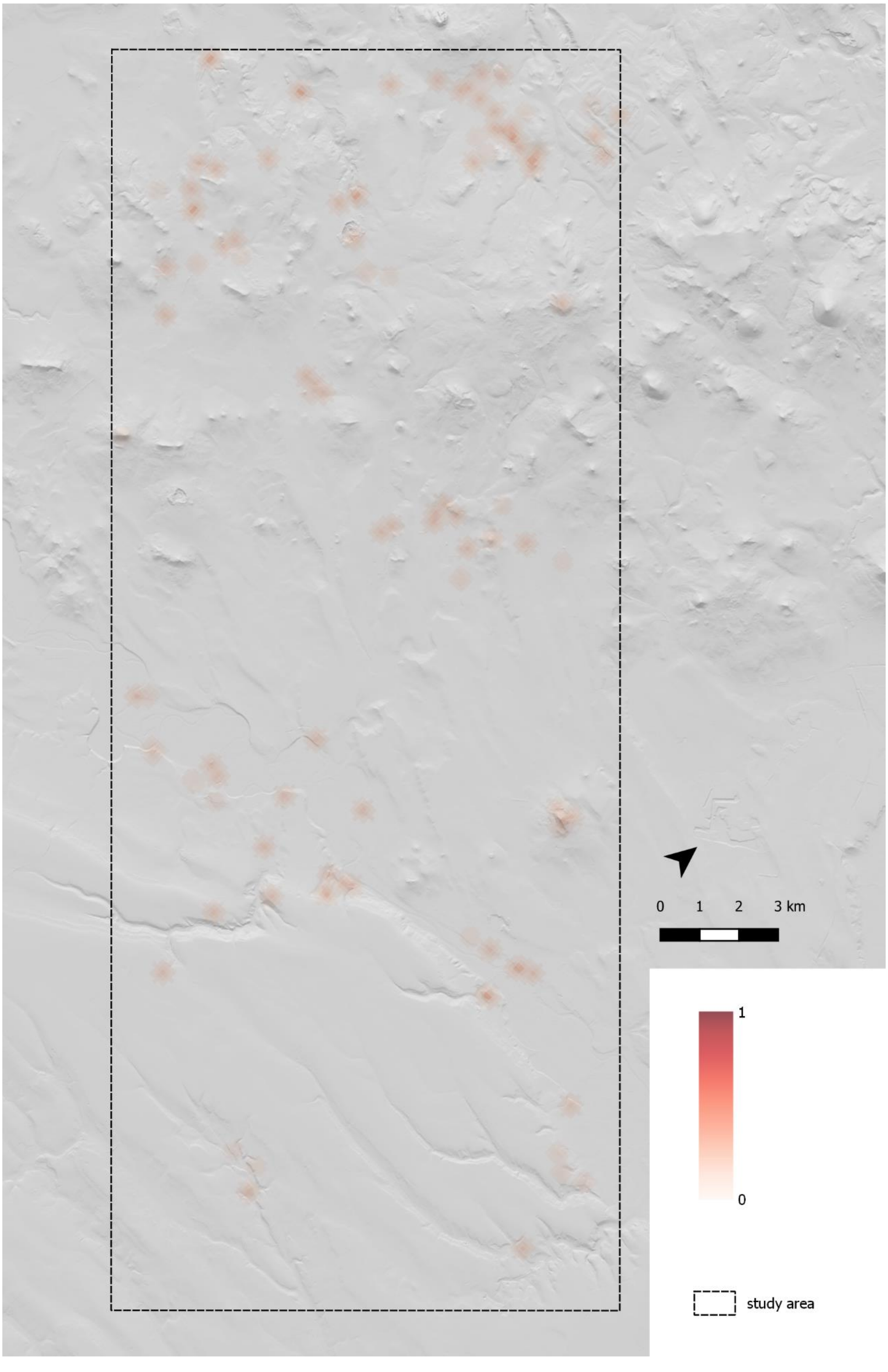
AMČR 2000 BC – 1600 BC



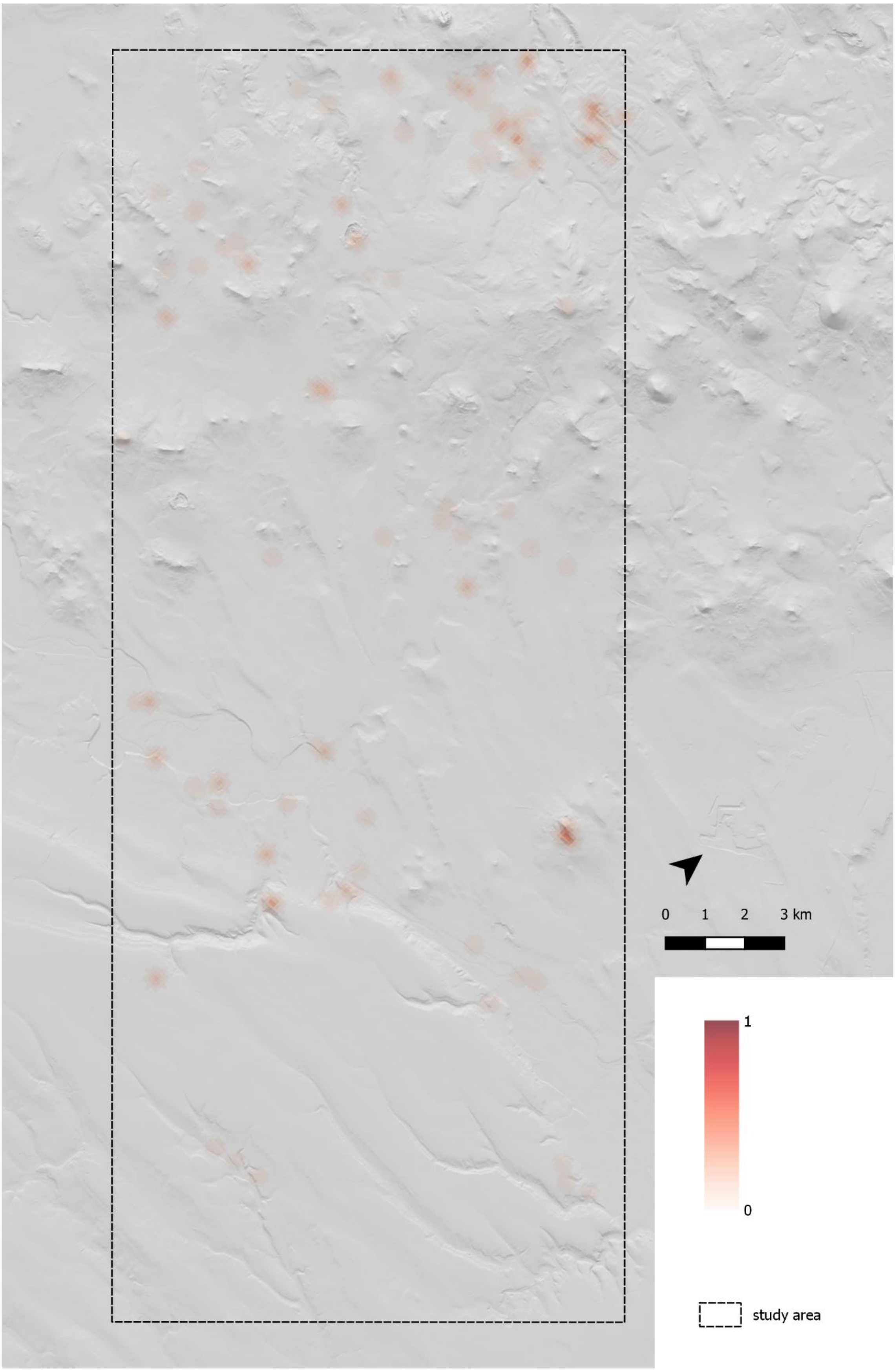
AMČR 1600 BC – 1200 BC



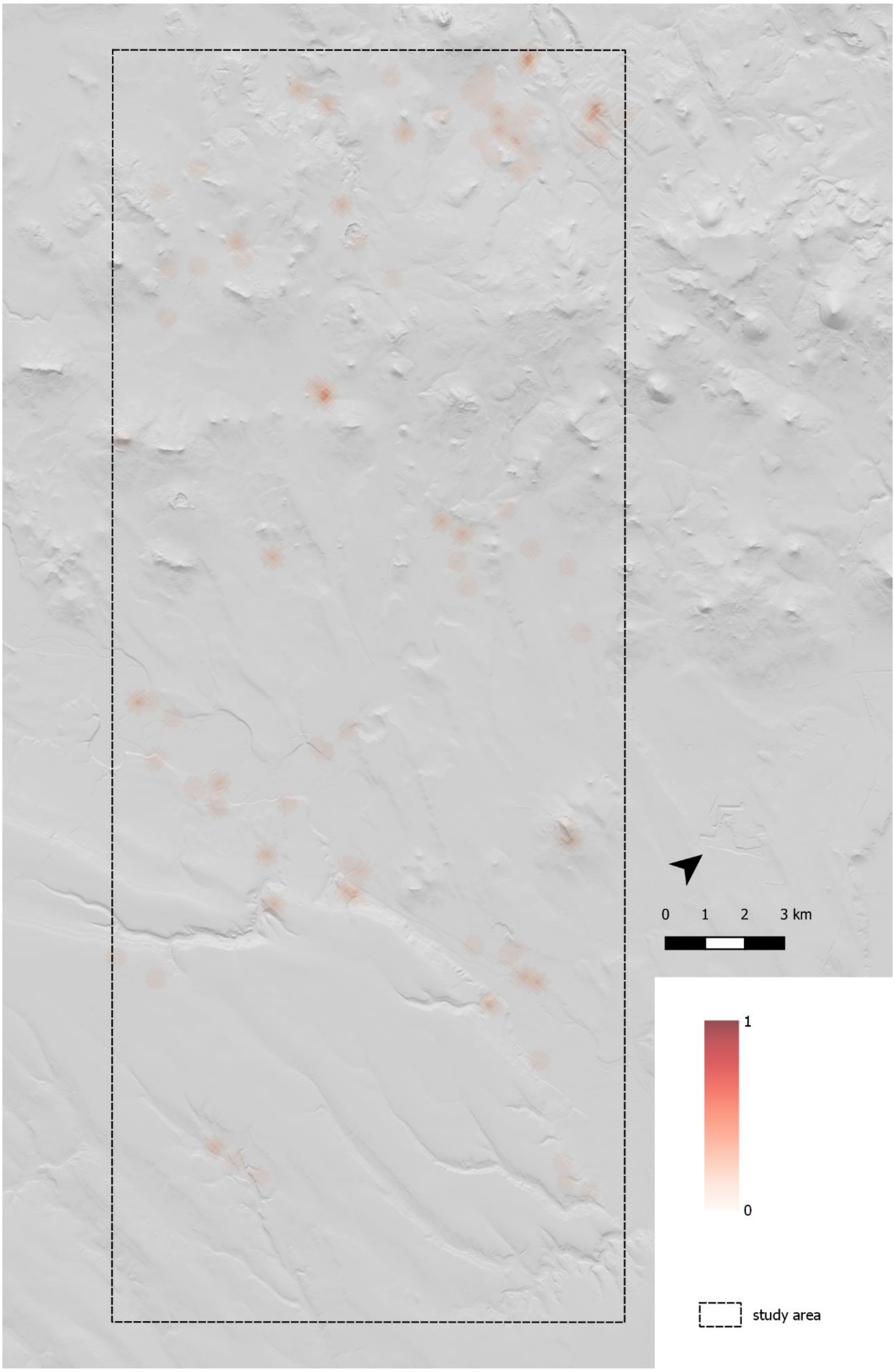
AMČR 1200 BC – 800 BC



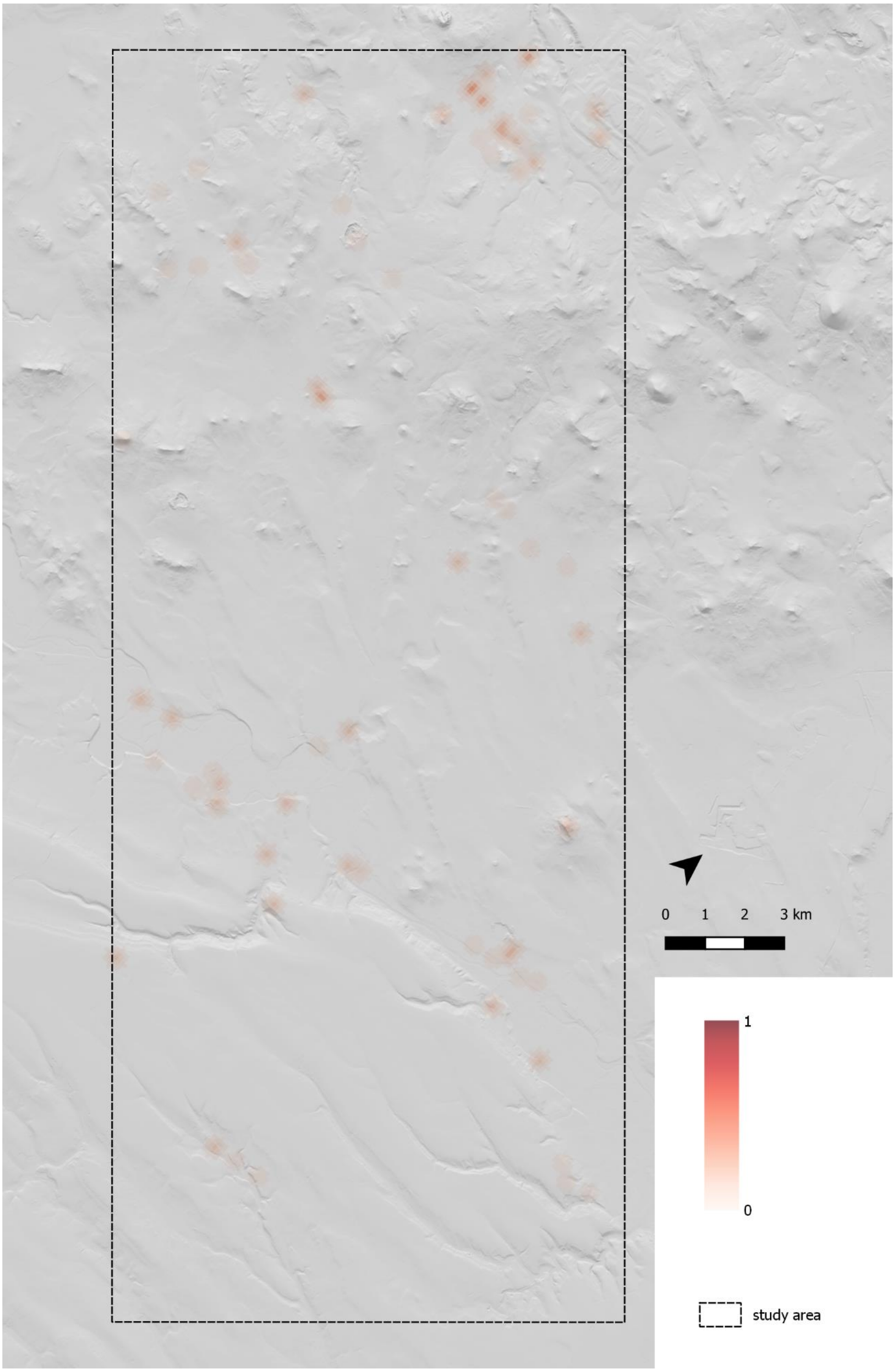
AMČR 800 BC – 400 BC



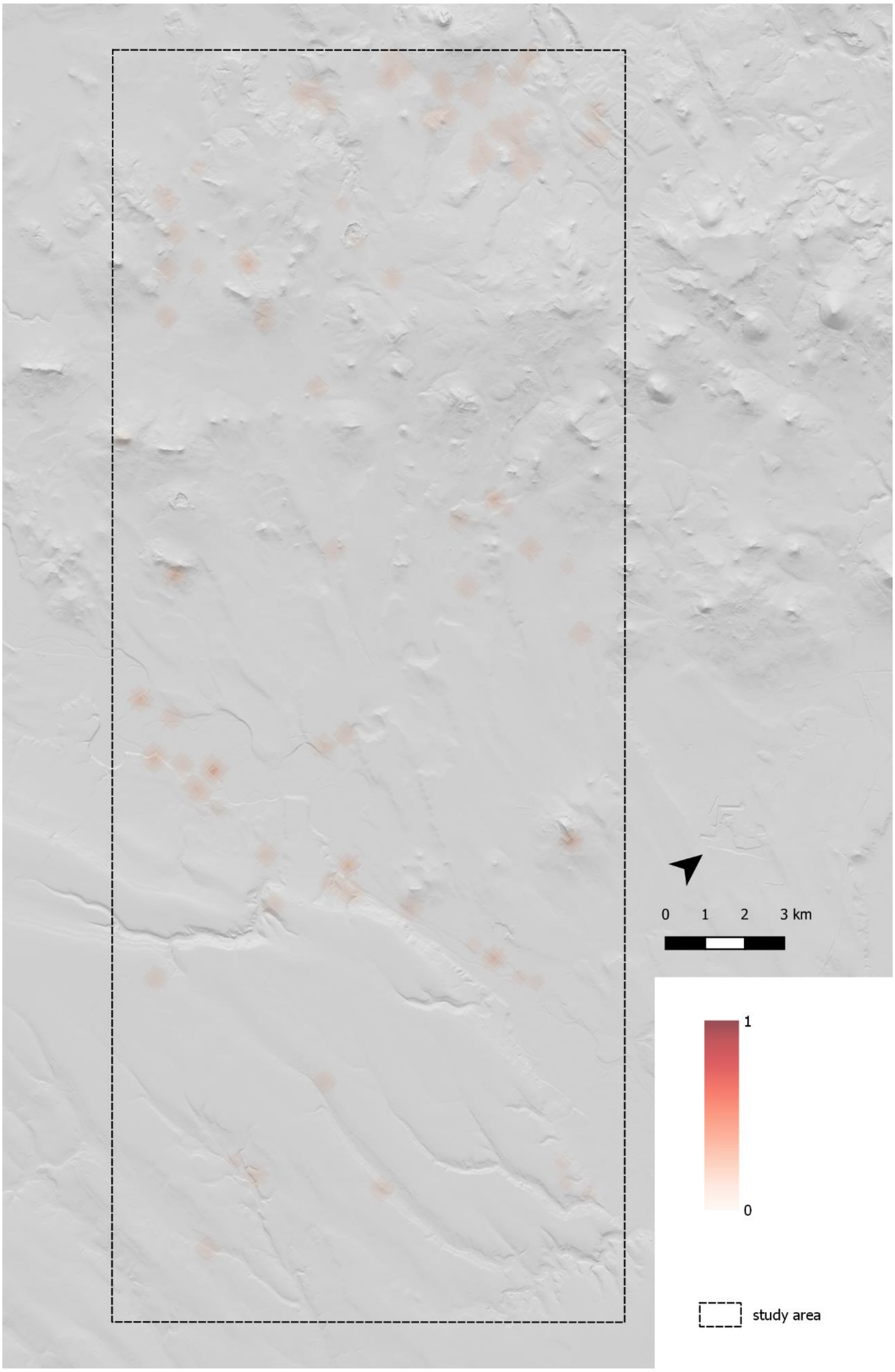
AMČR 400 BC – 0



AMČR 0 – 400 D



AMČR 400 AD – 800 AD



AMČR 800 AD – 1200 AD