4 The Neolithisation: A Micro-Regional Approach

As demonstrated in the previous chapters, the Neolithic early farming societies primarily emerged and expanded during the sixth millennium BCE in the Carpathian-Dnieper region. During these early stages, their dispersal mainly occurred through the migration of human groups, sometimes covering significant distances. These groups subsequently established themselves in new territories, cutting down forests, cleaning fields and building permanent settlements. However, these lands were inhabited by a local population: groups of fishers, hunters and gatherers equipped with pottery. What kind of influence local groups had on the process of Neolithisation? Had they interacted with newcomers, modifying their culture and adopting innovative traits from elsewhere? This question has been asked and will continue to be asked in relation to each region that has undergone Neolithisation. However, before examining these potential interactions, it is essential to establish with certainty whether these distinct human groups intersected in time and space: that there was a territory inhabited by both populations more or less during the same time. These spatial and temporal

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'windows of possibilities' are necessary but insufficient prerequisites for any interaction.

This problem is directly related to the spatial aspect of the life of human societies. It is about how groups of people with different economic backgrounds use space. In this context, space becomes an economic resource and an independent factor of production, crucial in creating static and dynamic advantages for groups operating within it. In essence, it emerges as a fundamental element in determining the competitiveness of a local production system. Therefore, we propose to shift our attention to the example of a separate, well-studied, and relatively well-dated micro-region inhabited in the period under question. Thus, let us turn to the Southern Buh region (SBR).

4.1 The Neolithic in the Southern Buh Valley: Concept and Range

The Neolithic of the Southern Buh Valley was destined to play a special role in Ukrainian Neolithic studies. Here, V.M. Danilenko discovered and studied what he believed to be perhaps the earliest evidence of agriculture and cattle breeding in Ukraine.[1] Local ceramic hunter-gatherers have long been perceived as farmers and pastoralists under significant Balkan influence.[2] Now, it is known that their acquaintance with agriculture was limited or non-existent.[3] Instead, the first remains of domesticated plants have been found at LBK settlements.[4] Accordingly, modern ideas about the time and nature of the Neolithisation of the Southern Buh Valley have changed radically. After the decline of LBK, the Precucuteni-Early Trypillian groups densely populated the region by founding their settlements and leaving their traces (ceramics and lithic tools) at fishing camps near the river rapids.[5] Later, Trypillian groups settled the region, and their settlements showed abundant evidence of contact with the mobile population of the steppe, such as specific types of ceramics and bifacial dart points.[6]

The Southern Buh is a major river flowing down the Podillia highland into the Black Sea, roughly southeast. It is 860 km long and has a catchment of 63,700 km^2. The river flows through the physical and geographical zones of forest-steppe and steppe. Its catchment is

1 Danilenko 1969.

2 Haskevych et al. 2019.

3 Motuzaite Matuzeviciute 2020.

4 Moskal-del Hoyo et al. 2023.

5 Burdo 1997.

6 Kiosak, Lobanova 2021.

located within several geostructural regions. The upper part of the basin is located on the Volhynian-Podillian Upland, the middle part is within the Dnieper Upland, and the lower reaches belong to the Black Sea Lowland.[7]

In its upper reaches, the Southern Buh flows through open wetlands in low banks and has the character of a typical lowland river: slow, meandering and relatively narrow. In the middle reaches, from the mouth of Ikva River to the mouth of Bakshala River, the Southern Buh forms a deep valley, 200-600 m wide, with rising banks (up to 90 m), almost everywhere steep and rocky. Its waters are much faster than upstream.[8] Here, the Ukrainian Crystal Shield comes to the surface, thanks to which the Southern Buh is known for its rapids, rifts, and rapid flows in the riverbed. They have been attractive fishing locations since ancient times. In the lower reaches (below the mouth of Bakshala River), within the Black Sea Lowland, the valley and channel of the Southern Buh widen considerably. The width of the riverbed reaches 2 km, and the flow practically stops. Below the mouth of the Ingul River (the left tributary), the Buh Lyman begins, which has the form of an estuary. Further, the Buh estuary joins the Dnieper estuary to flow jointly into the Black Sea.[9]

The Southern Buh catchment serves as a natural corridor uniting the hilly landscapes of Podillia and the Dnieper uplands on one side and the steppe Black Sea lowland's much flatter terrain. River terraces are not typically visible along the Southern Buh River, with only occasional steep cliffs separating the narrow floodplain from the loess-covered hilly plateau above.

The SBR has been home to the communities, characterised by their pottery-equipped fisher-hunter-gatherer way of life, since at least 5600 BCE, possibly even earlier.[10] The para-Neolithic sites in this region endured until the early fifth millennium BCE, aligning closely with some radiocarbon dates from that period.[11] The SBR boasts over 40 noteworthy para-Neolithic sites, including Gard, Puhach, Sokiltsi 1, 2 and 6, Haivoron-Polizhok, Zavallia, Zhakchyk, Savran, and Melnychna Krucha. Among these, Melnychna Krucha stands out with its several stratigraphic units of para-Neolithic habitation. The earliest layer (SU2) has been dated to 5977-5651 cal BCE (2σ), while the subsequent unit (SU-R4) falls within the range of 4973-4836 cal BCE (2σ).[12] At Gard,

7 Marynych 1990.

8 Doroshkevych 2018.

9 Konikov 2007.

10 Kiosak et al. 2021b.

11 Gaskevych 2014; Haskevych et al. 2019.

12 Kiosak et al. 2021b.

two distinct para-Neolithic layers were uncovered: a lower layer characterised by pottery in the Pechera style and an upper layer featuring Savran-style pottery. However, radiocarbon dating yielded dates that contradicted the observed stratigraphy, appearing in reverse order.[13] Criş potsherds have been sporadically discovered at para-Neolithic sites, yet these sites lack evidence of agriculture and herding.

Early farmers arrived in the region approximately between 5250 and 5100 years BCE with the expansion of the LBK.[14] The earliest direct evidence of an agricultural economy, including remnants of wheat, barley, and domestic animal bones, emerges during the LBK period.[15] In the Southern Buh Valley, there are four LBK sites and four stray finds of LBK potsherds. Two of them, Kamyane-Zavallia and Hnyla Skelia **[fig. 60: 8, 10]**, have yielded evidence of settlement structures (pits), confirming them as LBK settlements,[16] while the other two, Syne Ozero **[fig. 60: 7]** and Zhakchyk 3 **[fig. 60: 13]**, are identified based on surface material.[17] Four LBK stray finds are reported from para-Neolithic sites of Gard, Dobrianka 3, Schurivtsi-Porih **[fig. 60: 1]**, and Bazkiv-Ostriv. LBK settlements of the SBR have twelve AMS dates available,[18] which can be calibrated to the period of 5300-4950 cal BCE (2σ).

Following the LBK period, the next wave of early farmers to enter the region were Precucutenian (Early Trypillian) groups.[19] These Precucutenian groups are represented by 25 settlements. Habitation structures have been confirmed through excavations (Haivoron, Sabatynivka 2, Danylova Balka, Hrenivka, and Hrebeniukiv Yar, **[fig. 60: 2, 17, 18, 21]**) or habitation structures were detected directly on the surface at sites like Mohylna 1-5 **[fig. 60: 11-12]**. Furthermore, Precucutenian artefacts have been discovered in para-Neolithic contexts at sites such as Haivoron-Polizhok, Gard, Gard 1 and 2, and Puhach 1 and 2. The chronology of these settlements is supported by nine AMS dates,[20] ranging from 4675 to 4448 cal BCE (2σ).

The next phase (Trypillia B1/Cucuteni A) boasts a network of 51 settlements.[21] The most notable among these settlements is the extensively excavated Berezivska HES **[fig. 60: 15]**, spanning an estimated

13 Tovkailo 2014.

14 Moskal-del Hoyo et al. 2023.

15 Salavert et al. 2020.

16 Kiosak 2017; Kiosak, Radchenko 2021.

17 Peresunchak 2018.

18 Kiosak et al. 2021b; Moskal-del Hoyo et al. 2023.

19 Burdo 1997; Zbenovich 1996.

20 Kiosak et al. 2021b.

21 Burdo 2015; Peresunchak 2012; Peresunchak 2015.

area of about 10 hectares.[22] Sabatynivka 1, Borysivka, Krasnostavka, etc., were also subject to excavation,[23] while the sites of Topoli, Kozachyi Yar I-II, Kamyane-Zavallia I, Shamrai and some others are known through test trenches and surface collections. Geomagnetic surveys have revealed that ditches surrounded dwelling areas at Kamyane-Zavallia I and Kozachyi Yar I.[24] Radiocarbon dating has placed these sites within 4339-4054 cal BCE (2σ).[25]

Thus, the SBR is situated on the periphery of the early farming expansion. Early farmers settled this area during various periods spanning from the sixth to the fourth millennium BCE.[26] As a result, the region has revealed at least three distinct chronological horizons of Neolithisation: LBK, Precucuteni, and Trypillia B1.

The environmental setting for this development is still insufficiently studied.

The palaeobotanical analysis yields significant insights, indicating that by the late seventh millennium BCE, the Southern Buh riverbank in the SBR was characterised by an alluvial deciduous forest dominated by ash, oak, and elm. This forest ecosystem endured throughout the LBK period, extending into the final quarter of the sixth millennium BCE.[27] At the LBK site of Kamyane-Zavallia, on-site evidence of cereal processing was discovered, with remnants of *Triticum cf. dicoccum*, *Triticum cf. monococcum*, and *cf. Hordeum* identified. Additionally, weed macroremains such as *Chenopodium album* and *Fallopia convolvulus* suggest the transformation of certain forest areas into arable fields by this period, affirming the establishment of an agricultural landscape in the SBR between 5250-5050 cal BCE.

Pollen data from several pollen cores (Troitske and Yelanets) closely align with the palaeobotanical observations.[28]

In the steppe region of the Southern Buh River valley, extensive research has been conducted on the Troitske bog over the years. M.I. Neustadt dated the sedimentary stratum he investigated to the early Holocene era, whereas O. Artiushenko suggested that the bog formation commenced during the late Pleistocene. More recently, L.G. Bezusko provided palynological data from the Troitske-II core, shedding further light on its characteristics,[29] sampled and dated in the 1980s.

22 Tsvek 2004.

23 Dobrovolskyi 1952.

24 Saile et al. 2016b; Saile et al. 2021.

25 Kiosak, Lobanova 2021.

26 Kiosak et al. 2021b.

27 Moskal-del Hoyo et al. 2023; Salavert et al. 2020.

28 Bezusko 2010; Kremenetski 1995.

29 Bezusko 2010.

As per the findings of the Ukrainian researcher, a twelve-meter sedimentary sequence began forming at the onset of the Atlantic Holocene, approximately 7,000 years ago (uncalibrated), when an ancient lake transitioned into a peat bog. This period was characterised by the prevalence of grasses and shrubs, particularly quinoa and forbs. Subsequently, the spore-pollen complex exhibited a similar structure with a gradual increase in the proportion of forbs, although some samples displayed notably high levels of *Artemisia*. Above this layer, there was a sediment layer exceeding one meter (170 cm) in thickness, where, despite a comparable ratio of pollen from various vegetation types, grasses assumed a more prominent role on average, and cereal pollen appeared for the first time, alongside isolated weed pollen grains. Radiocarbon dating yielded an age of 4960 ± 200 BP (IGAN-801, calibrated to 4320-3450 calBCE, 2σ) for this layer. The absence of additional radiocarbon dates and the wide standard deviation in the conventional date precludes a direct comparison between L.G. Bezusko's findings and the climate trends of the late Early to early Middle Holocene. Nonetheless, her observation regarding the prevalence of steppe vegetation in the vicinity of the Troitske bog during this period, coupled with the substantial growth of gully and floodplain forests, holds significant importance.[30]

The Yelanets 2 soil section is located on the territory of the Yelanets Steppe Nature Reserve (Mykolaiv oblast, Ukraine). The sediments are 1 m thick. The sediments in the section represent the Early (BO) to Late Holocene (SA) time interval.[31] The Early Holocene is dominated by pollen from steppe vegetation, with significant participation from grasses. Pollen from meadow vegetation, which existed in more humid areas, is also found. In the Middle Holocene, the role of meadow pollen and tree and shrub pollen increased significantly, and its content fluctuated throughout the period. The section is well-dated, but its small thickness is sufficient only for generalised vegetation characteristics.

The lower stretches of the Southern Buh river cut the Black Sea lowland, a geomorphological counterpart to the western expanse of the Great Eurasian Steppe. We may anticipate that the steppe zone experienced expansion and contraction during the Holocene.[32] However, there were areas with nearly constant steppe vegetation dominance, as evidenced by Troitske and Yelanets 2 cores. The SBR, from a purely geographical perspective, consistently represented a natural contact zone between populations from these two distinct environmental zones, namely steppe and forest-steppe.

30 Bezusko 2010.

31 Bezus'ko, Bezus'ko 2000.

32 Smyntyna 1999.

4.2 Looking for Interaction in Time

In the Southern Buh region, the radiocarbon chronology of early farmers is based on two datasets: conventional dates from the Kyiv radiocarbon facility, which appear to be notably earlier than other dates[33] and more recent AMS dates from the laboratories at LARA (University of Bern), Poznan, etc.[34] Due to the issues reported with the former dataset,[35] we will rely on the latter dataset. This dataset consists of 30 AMS dates, with twelve associated with two LBK sites, nine with four Early Trypillian sites, and nine with three Trypillia B1 sites **[fig. 61]**.

Bayesian modelling was conducted using OxCal software to explore the region's presumed episodic nature of human settlement. The Interval function estimates the gap between different sequential phases of occupation, each formed by the dates associated with a particular cultural aspect, with a certain probability. Notably, the interval between the LBK and Early Trypillian phases is quite pronounced, ranging from 222-637 years (with a likelihood of 95.4%) or 411-578 years (with a 68.3% probability). The second gap between the Early Trypillia and Trypillia B1 phases is comparatively shorter, spanning 34-256 years (95.4%) but most likely 118-220 years (68.3%). Of course, this observation does not mean complete depopulation for the entire Carpathian-Dnieper region.[36] For example, between the LBK and Trypillia A, early farmers densely inhabited the Lower Danube and the slopes of the Carpathians.[37] However, they were absent from the Southern Buh Valley.

Moreover, since the dates for each phase exhibit high consistency, we can consider them related to the same episode of human activity rather than treating each date as a potentially independent event, as in the previous model. Under this more straightforward approach **[fig. 61]**, the LBK phase lasted from 5213-5050 cal BCE (95.4%), the Early Trypillian phase ranged from 4603-4461 cal BCE (95.4%), and the Trypillia B1 phase spanned 4331-4243 (95.4%). The calibration of LBK dates extends across the entire duration of the notorious late sixth-millennium plateau, a known challenge for dating LBK.[38]

It is important to note that the Early Trypillian sites in the SBR region correspond to the later typological phases of this cultural aspect

33 Kiosak et al. 2023c.

34 Kiosak et al. 2021b.

35 Gaskevych 2014; Kiosak et al. 2023c.

36 Kiosak, Radchenko 2023.

37 Garvăn et al. 2009.

38 Lenneis, Stadler 1995.

and should follow the earlier sites of Precucuteni I-II and Trypillia A1-2.[39] The same is true for Trypillia B1 sites, which align with the Cucuteni A3 stage, while preceding sites of Cucuteni A1-2 are located to the west, on the hilly slopes of the Carpathians.[40] Consequently, continuous development occurred in other areas while the SBR region experienced population influx and depopulation.

As shown in Chapter 2, the para-Neolithic groups mainly existed in two time periods: 5900-5400 BCE and 5050-4700 BCE. While the first group of dates does not correspond to any early agricultural settlements in the SBR and, thus, is not interesting from the point of view of looking for coexistence, the second group, on the contrary, may indicate potential overlap with the dates for early farmers.

Therefore, we added a phase with the dates of the second para-Neolithic time block to the model in Oxcal (six dates). Two models were created: overlapping and sequential [**models 4-1; 4-2**]. The sequential model fails validation by the χ^2 criterion. Some dates converge poorly with the model in general; however, there is enough time to separate LBK, para-Neolithic and Early Trypillia. Namely, LBK dates mostly fell in the timeslot before 5000 years, while para-Neolithic dates post-date this margin. Para-Neolithic dates mostly fell into timeslot before 4550 BCE, while Early Trypillian dates mostly concentrated after this conventional boundary **[fig. 62]**. So, these three cultural aspects could exist in sequence without meeting each other. On the other hand, the model with overlapping phases has even better indices. Accordingly, the coexistence of the para-Neolithic groups with the LBK, especially with the Early Trypillia, is likely **[fig. 63]**. Nevertheless, despite this observation, the calibration errors are pretty large, and there is still time to separate the early farmers and hunter-gatherers. For this purpose, there is a sufficiently long gap between the decline of the LBK and the arrival of the early Trypillians.

In this analysis, the representativeness of the radiocarbon record remains a significant concern, as it is far from being comprehensive for the SBR. Nevertheless, the observed punctuated pattern of early farmers' presence[41] in the region cannot be ignored. While the gaps could potentially be addressed by expanding the dataset, it is likely that both gaps genuinely reflect the fluctuations in early farmer activities in the region during these two specific time intervals. Noteworthy, ceramic hunter-gatherers' activities are particularly well represented in the dataset during the absence of early farmers in the region: before the expansion of LBK and after the demise of LBK until the expansion of Precucuteni.

39 Garvăn et al. 2009.

40 Sorochin 2002.

41 Kiosak, Radchenko 2023.

4.3 Looking for Interaction in Space

Let us focus on archaeological sites' spatial distribution to uncover continuity and discontinuity patterns.

In the SBR region, the settlement patterns do not precisely overlap when viewed through a diachronic lens. There are no instances of LBK sites being resettled during Early Trypillian times, nor are there cases of Early Trypillian sites being reused during Trypillia B1. Some para-Neolithic sites yielded finds of LBK potsherds and Early Trypillian artefacts.

While some reports mention the discovery of Trypillian artefacts in earlier contexts,[42] there are no instances of true interstratification where an earlier site is found beneath a later one. Such stratified sites have been documented in other regions[43] but are notably absent from the SBR.

A. Topographic Position

To quantify this pattern, distances to the nearest neighbour from a different cultural aspect were considered. On average, Early Trypillian settlements are approximately 8.98 kilometres away from their nearest LBK neighbours (ranging from 1.81 to 19.86 kilometres). At the same time, LBK sites are typically closer to Trypillia B1 sites, with an average distance of 6.27 kilometres (ranging from 0.64 to 17.67 kilometres). The distance between Trypillia A and B1 sites is notable, ranging from a minimum of 2.71 kilometres to a maximum of 11.94 kilometres, with an average of 6.9 kilometres. The para-Neolithic sites are sometimes situated very close to early farming sites, with numerical proximity more in line with Trypillia B1 sites, even though the para-Neolithic predates the duration of the middle stage of Trypillian culture in the Southern Buh valley.[44]

Catchment analysis for early farmers typically operates within a 1-5 kilometre radius of the site.[45] Considering the distances between the sites mentioned above, some sites from different periods fall within this range of their nearest neighbour from another cultural aspect. For example, Early Trypillian sites in the Mohylna area are located within 1.25-4 kilometres of the Zhakchyk III site, which yielded LBK finds. In some cases, Trypillia A and B1 settlements were in close proximity, with sites like Tashlyk and Berezivska HES being

42 Burdo 2015.

43 Passek, Chernysh 1963.

44 Burdo 2015; Haskevych et al. 2019.

45 Diachenko, Menotti 2012.

separated by 3.28 kilometres, while Sabatynivka II and Sabatynivka I were 2.71 kilometres apart. Trypillia B1 sites are sometimes found in close proximity to LBK sites, such as Kamyane-Zavallia and Kamyane-Zavallia I, with a distance of 650 meters between them. However, these sites are separated by a gap of 600-800 years in terms of human activity, and the later sites are usually located in somewhat different topographic positions.[46]

Some para-Neolithic sites are located in close proximity to early farming sites. For instance, LBK sites like Hnyla Skelia and Kamyane-Zavallia were on the western bank of the Southern Buh, while just a few kilometres downstream on the opposing eastern bank, there were para-Neolithic sites of Zavallia and Zhakchyk, though these para-Neolithic sites remain undated. The site of Haivoron-Polizhok stands near the Early Trypillian settlement of Haivoron and yielded some Early Trypillian potsherds. The para-Neolithic site of Zhakchyk was recovered near the Trypillia B1 settlement of Berezivska HES.

The spatial distribution of sites also varies in terms of their landscape positioning. LBK sites are typically located along the banks of the Southern Buh River (in three cases) or inland on a bank of the Mohylianka River (a first-order tributary of the former). They are situated on fertile, flat, low terraces just a few meters above the floodplain or on high plateaus sloping down to the river. Typically, there is some distance between the site and the closest water source, ranging from 50 to 250 meters. These sites are presently situated on 'deep chernozems with a little humic content'. While numerical data for LBK settlements in SBR are still insufficient, we can refer to the sites from the nearest region of intense settlement of LBK – namely, the Republic of Moldova, as presented by O. Larina (1999). Her study of 53 LBK settlements between the Prut and Dniester rivers exemplifies this. Most LBK sites (81%) are situated away from watercourses, primarily on terraces (65%) or terrace slopes (35%). Only a few settlements (15%) are nestled within large river valleys, with none on islands. LBK communities favoured locations with ample flat space nearby, likely for agriculture.

In contrast, Trypillia A sites show a significantly different spatial pattern in the SBR. Most sites are located inland on small tributaries of the first and second order. There are exceptions, with two cases situated on the bank of the Southern Buh, and the site of Krasnenke was found on an island. The distance to the closest water source ranges from zero (for sites on an island) to 300 meters. Most sites are situated on deep chernozems with a little humus content, while a single site is in a sandy area near the bank of the Southern Buh. One site, Mohylna 3, revealed buried soil under Trypillian dwelling debris,

46 Kiosak, Radchenko 2023.

suggesting a fertile, humic-rich horizon similar to chernozems was present during the Trypillian period. Early Trypillian potsherds are often found in the para-Neolithic sites, sometimes hundreds of pieces. Namely, they were found in Shumyliv-Cherniatka, Haivoron-Polizhok, Gard, Gard 3 and 4, and Puhach 1-2 from the SBR.

Trypillia B1 sites, on the other hand, are situated along the banks of the Southern Buh or inland (most sites). Geomorphologically, they are found on high plateaus or terraces rising 3-6 meters above the floodplain. They can be immediately adjacent to watercourses or slightly inland (250 meters from the river). Around a third of these sites are located on the modern-day 'deep chernozem with a reduced humic content', while the others are on regraded chernozems. These regraded chernozems represent soils that were formerly under forests and are in the process of acquiring the qualities of typical chernozems. Thus, Trypillia B1 sites were detected in different pedological contexts, closer to existing forests and wooded areas.

Despite extensive forest management in the region since the late eighteenth century,[47] there are naturally forested areas with limited human interference, primarily in the higher portions of the plateau and steep slopes of deep Pleistocene gullies. Most Trypillia B1 sites are located in such areas, suggesting that the people of Trypillia B1 actively sought a more wooded landscape. Palaeopedological analysis conducted at the Sabatynivka I site (situated on deep chernozems with reduced humic content) revealed a typical soil with a shorter humic horizon, similar to the so-called 'southern chernozems'.[48]

In summary, there are apparent differences in the spatial patterns of each early farming cultural aspect that settled in the SBR region, encompassing qualitative (distance) and quantitative distinctions, such as varying topographic positions and underlying soils selected by early farmers during different phases of colonisation. However, there is still potential for continuity in cultural landscapes in certain parts of the region.

In contrast, the para-Neolithic settlement pattern, as described by V.M. Danilenko, V.I. Marchevici, and M.T. Tovkailo, is very different.[49] Analysis of 50 sites along the Southern Buh valley and its tributaries reveals a preference for riverside locations (60%), often close to rapids or cliffs. A significant proportion (88%) are found along the banks of large rivers like the Southern Bug and Ingul, with some on river islands or elevated terraces. Most recorded para-Neolithic sites are situated in floodplain elevations or terraces. Many sites were recorded

47 Kordt 1931.

48 Lobanova et al. 2021.

49 Danilenko 1969; Markevich 1974; Tovkailo 2005.

on islands, for example Haivoron-Polizhok was found on the Solhutiv island, while another site, Melnychna Krucha, stood on a promontory that could have been an island in prehistory. Several sites, Zavallia, Gard 3-4 etc., were located in a higher position (40-50 meters above the river) at the valley's edge.[50] Many sites are near rapids, directly on riverbanks, or less than 50 meters from the watercourse, along the large Southern Buh River.

These distinctions imply differing spatial organisations: early farming settlements focus on agricultural expanses along small rivers and creeks, while hunter-gatherer sites favour proximity to major rivers, likely for fishing and river-related activities. This suggests that LBK communities sought arable land, while para-Neolithic populations prioritised access to water resources. These variances hint at diverse mobility cycles and economic strategies within the same geographical region, where competition for resources was limited due to partially overlapping economic needs.

B. Buried Soils

Another aspect worth considering is the soils on which early farmers and hunter-gatherers lived and worked. We would expect significant differences based on a general understanding of these two economic systems. The diachronic aspect should also be considered: soils are a historical phenomenon. They are born, evolve, are transformed into other soils, and disappear due to erosion. Accordingly, the above comparison of modern soils, on which the sites of both entities (para-Neolithic and early farmers) were found, may not be sufficient. Fortunately, in the SBR, the Holocene sedimentation was often so extensive that sometimes ancient Holocene soils were buried under later sediments and were available for direct study. Pedological analyses conducted by Zh.M. Matviishyna at several sites[51] revealed that when preserved, buried soils belonged to several morphological types similar to those found in the region today.

The buried soils were revealed in several sites of early farmers. The soil analysis at Kamyane-Zavallia, the only LBK site studied in this manner **[fig. 63: 12]**, unveiled traces of the buried soil. The contemporary soil is a fertile chernozem characterised by a light clay loam morphology. Micromorphological analysis hinted at the faint presence of buried soil at a depth corresponding to the anticipated walking surface (-50 to -85 cm). This buried soil, appearing dark grey or blackish and loose with blocky-granular texture, displayed

50 Danilenko 1969.

51 Matviishyna, Kushnir 2018; Matviishyna, Doroshkevych 2019.

a humic-clayish cover around each sand grain, indicating fertility akin to the present-day local soil. Thus, we face a fertile, humic, short-profiled soil developed on loess. This arable soil likely existed during or slightly after the LBK habitation.[52]

At the Mohylna 3 site [fig. 63: 14], Early Trypillian farmers utilised a fertile soil transitional to kastanozems, indicative of arid conditions during its formation. The buried soil was notably rich in humus and organic carbon.[53]

During the Trypillia B1 period (4400-4200 BC), farmers constructed settlements on mollic fluvisol formed on sandy alluvial deposits or chernozem formed on alluvial silts. These buried soils boasted thick humus horizons, signifying fertility.[54] Later stages of Trypillia in nearby regions of the Dnieper River basin also utilised chernozem soils.[55] At Sabatynivka 1 [fig. 63: 15], chernozem development was halted by a late fifth millennium BCE erosional event, a chronology potentially applicable to Mohylna 3 and Kamyane-Zavallia 1.[56]

In contrast, ceramic hunter-gatherers settled on different soil types. Their remains were discovered above silty alluvial deposits at Melnychna Krucha [fig. 63: 6] and within marshy-fluvial layered sediments at Mykolyna Broiaka [fig. 63: 7].[57] Although modern soils at both sites are suitable for agriculture, those available during the sixth to fifth millennia BC appeared unsuitable, prompting human settlement along riverbanks, likely for fishing, hunting, and gathering.

Chernozem was reconstructed by Zh.M. Matviishyna for the 'Neolithic' period layers at Dobrianka 1 and 3 [fig. 63: 1] in the Velyka Vys river valley.[58] However, taphonomic complexities and diverse dating results suggest that these chernozems might have formed later, incorporating materials from the 'Neolithic' cultural layer.[59]

The Gard [fig. 63: 8] site presented a sequence extending approximately 3 meters deep. The lower layer, a para-Neolithic layer rich in lithic tools and pottery,[60] featured a H(p) horizon of mollic fluvisol that developed from the parent material of alluvial sandy loam under conditions of periodic flooding. The upper layer contained the 'Late

52 Kiosak, Matviishyna 2023.

53 Kiosak, Matviishyna 2023.

54 Lobanova et al. 2021.

55 Dreibrodt et al. 2022; Matviishyna et al. 2014.

56 Kiosak, Lobanova 2021; Lobanova et al. 2021.

57 Kiosak, Matviishyna 2023.

58 Matviishyna, Parkhomenko 2007.

59 Kiosak 2019b.

60 Tovkailo 2014.

Neolithic' layer with abundant hunter-gatherer ceramics and Trypillia A potsherds,[61] which was formed in subaerial conditions, suggesting some limited agricultural suitability.[62] At the Lidyna Balka site [fig. 63: 8], the para-Neolithic layer corresponded to gleyic mollic fluvisol, which was subjected to excessive moisture.[63]

Thus, our findings regarding buried soils from hunter-gatherer sites support the pronounced difference with early farmers. Among the seven reported cases, four revealed para-Neolithic remains corresponding to the soils, which developed in moist conditions, often due to seasonal flooding. Such soils are hardly suitable for agriculture. Limited agricultural activities (gardening) were possible on the soil of the upper horizon of Gard. Additionally, in two instances where chernozems were identified alongside artefacts of ceramic hunter-gatherers, doubts arose regarding the reliability of the chronology due to taphonomic factors. Thus, the chronology of these soils remains uncertain. In contrast, every early farming site under investigation exhibited fertile soil: three instances of various chernozems and one instance of mollic fluvisol, characterised by rich humus content and a well-developed profile.

C. Visibility Analysis

Visibility often serves as a proxy for confirming the inclusion of particular objects within a shared settlement pattern with other sites.[64] To assess the spatial dynamics of interactions between settlements and to examine the relationship between specific settlements in their respective chronological contexts with their surrounding environments, we conducted least cost path and viewshed analyses with the QGIS geospatial software, using open data from the Shuttle Radar Topography Mission[65] for the sites of particularly densely settled Middle Southern Buh region [fig. 60].

We systematically considered mutual visibility for chronologically proximate sites belonging to the same archaeological culture. Specifically, for sites from the LBK, we assessed their mutual visibility with other LBK sites and those from the para-Neolithic [fig. 65]. Para-Neolithic sites were examined with LBK and Trypillia A sites [figs 66-67], whereas Trypillia B1 settlements were only evaluated

61 Tovkailo 2014.

62 Matviishyna et al. 2015.

63 Matviishyna et al. 2015.

64 Brughmans, Brandes 2017.

65 Kiosak, Radchenko 2023.

within their group [fig. 68]. Our analysis compared mutual visibility with the least cost paths between sites.[66]

Upon comparing and analysing the acquired results, a discernible pattern emerges, characteristic of each early farming occupation. Each phase of early farming occupation had a 'core area'. This core area represents a confined territory where multiple settlements enjoy direct visibility and/or significantly shorter distances between them. Conversely, there exists a group of sites that lack such direct visibility and are often positioned at considerable distances beyond a specific threshold. The terrain between sites with mutual visibility can be termed 'shared territory'. Even if these sites were not contemporaneous, there could be a continuity of land use by inhabitants who had shifted their settlements slightly. It is conceivable that these 'core areas' depicted cultural landscapes characterised by cleared forests, cultivated fields, and pastures. While empirical research is necessary to validate this hypothesis, spatial analysis data hint towards this possibility.

The pattern of settlements with a 'core area' and dispersed sites finds similarities in spatial patterns well-documented in Western Europe.[67] These patterns are often interpreted as a result of the diachronic development of pioneering communities establishing new sites during demographic growth and subsequent expansion. However, the critique of this 'micro-regional demic diffusion' idea has led to other models suggesting the parallel development of multiple communities in more than one region.[68] The interpretation of these patterns will depend mainly on the chronological sequencing of sites, necessitating further research, including serial AMS dating and typochronological studies of material culture.

Different trends are observed among para-Neolithic sites in the region despite their lack of direct visibility with one another. If, between the agricultural settlements, there is a certain area of land that can theoretically be available for cultivation, then between the para-Neolithic sites, there is a river. Their distribution is characterised by a linear pattern that tends to the riverbanks, while early agricultural settlements are also located deeper inland, covering certain areas of common viewshed. The proximity of Trypillia A's Haivoron and the para-Neolithic Haiviron-Polizhok sites, along with the proximity of Zavallia and Zhakchyk to Hnyla Skelia (an LBK site on the opposite side of the Southern Buh River), may carry significance. However, the absence of clear chronological information complicates interpretation.

66 Kiosak, Radchenko 2023.

67 Zimmermann et al. 2004; Zimmermann et al. 2009.

68 Bickle, Hofmann 2009.

Analysing settlements of the same culture concurrently sheds light on distinct localisation patterns, revealing diverse modes of habitation and interaction with the cultural landscape in the daily lives of prehistoric populations in the area. Occasionally, para-Neolithic sites were situated near LBK or Early Trypillia sites, which might have been contemporaneous with the para-Neolithic in the Southern Buh valley. Nevertheless, mutual visibility was largely absent. For instance, LBK sites along the western bank of the Southern Buh could be observed from the para-Neolithic site Zavallia. However, the latter primarily comprised surface finds without evidence of prolonged human presence.[69] Similarly, the Zhakchyk site was close to the Trypillia B1 site of Berezivska HES;[70] however, this likely indicates subsequent occupation of a similar location along the Southern Buh River. The dates of Trypillia B1 postdate those of the local para-Neolithic sites. Therefore, even if para-Neolithic groups were contemporary with early farmers, these fishers, hunters, and gatherers equipped with pottery remained largely unseen by the latter.

4.4 Conclusion

Every time prehistoric agriculturalists inhabited the region, a distinct settlement pattern emerged. Various interpretations can elucidate this observation: changing climate, evolving preferences of early farmers for suitable land, the settlement patterns of local para-Neolithic groups with an extractive economy limiting the options of early farmers, intentional avoidance, and varying starting points of development. We have proposed **a discontinuous model** for the Neolithisation of the Southern Buh region to account for the empirical data in radiocarbon dating and settlement patterns.[71] Thus, phases of Neolithisation were probably separated by periods of retreat and demise of early farming communities.

Comparing the available radiocarbon dating records with settlement data reveals significant regional demographic fluctuations. Continuous settlement patterns did not link successive periods of Neolithic colonisation. Spatial analysis reinforces the radiocarbon data, highlighting an interrupted presence of groups engaged in agriculture in the SBR region. The exact nature of this 'de-Neolithisation processes' poses an intriguing problem to solve. The interrupted population of the region indicates that early farmers on the periphery of their distribution were susceptible to environmental changes, and it

69 Gaskevych 2005.

70 Tsvek 2004.

71 Kiosak, Radchenko 2023.

took several attempts to establish sustainable farming in the fertile soils of Central Ukraine.

In the Southern Buh Region (SBR) region, there is a scarcity of overlapping settlements from different early farming cultural phases. Mutual visibility is quite limited between consecutive occupation periods. LBK sites were distant from Early Trypillian settlements, and the latter were separated from Trypillia B1 sites. The 'core areas' of LBK and Early Trypillia, as well as Early Trypillia and Trypillia B1, do not intersect, indicating interruptions in the development of cultural landscapes. Each early farming group essentially 'tamed' the SBR region independently, irrespective of the accumulated landscape features of their predecessors. A 600-800-year gap between LBK and Trypillia B1, even with the partial overlap of their 'core areas', makes it highly improbable that LBK's features persisted until the time of Trypillia B1.

If this hypothesis is substantiated, it could offer a novel perspective on Neolithisation. The conventional notion of uninterrupted 'progress' is an inadequate representation of the actual processes of establishing productive economies. These processes involved setbacks and 'retreats' of early farming areas. The depopulation of the SBR region during the early fifth millennium BCE aligns with the 'Middle Neolithic' crisis, a period marked by a decline in early farming populations across various Central European territories.[72]

The region's indigenous fishers, hunters, and gatherers seem to have actively responded to fluctuations in early farming groups. Several para-Neolithic sites have been dated to approximately 4950-4750 years BCE. Melnychna Krucha R4, for example, contained para-Neolithic pottery and was dated to 4973-4836 (2σ) cal BCE. AMS dates ranging from 5211-4491 cal BCE were obtained from potsherds with a similar style to those found at Melnychna Krucha.[73] Other para-Neolithic sites in the Dniester valley revealed similar patterns. Thus, after the disappearance of LBK, there was a resurgence of fishers, hunters, and gatherers with para-Neolithic ceramic vessels. Adaptations based on an extractive economy seemed to have successfully 'regained terrain', at least temporarily.

At the same time, the chronological analysis indicates that there is a rather significant period when the last hunter-gatherer sites and early Trypillian settlements could have existed simultaneously in the SBR, around 4700-4550 BCE. The spatial analysis identifies several micro-regions where early farmers' sites directly border on hunter-gatherer camps: near the town of Haivoron, the Early Trypillian settlement and the Haivoron-Polizhok site **[fig. 67: 1]**, in the

72 Amkreutz; van de Velde 2018.

73 Haskevych et al. 2019.

area of the LBK settlement of Hnyla Skelia **[fig. 65: 2]**, and around the cluster of para-Neolithic sites near Gard.[74] The multi-criteria assessment indicates different uses of space by early farmers and their hunter-gatherer neighbours. The former settled micro-regions both along the banks of the main river (the Southern Buh) and quite far inland. The latter camped along the main river, mostly near rapids and on islands. The former were looking for areas with fertile soil, while the latter's camps gravitated towards places convenient for fishing, even if the soil around them was not at all favourable for growing plants. Therefore, early farmers and hunter-gatherers could coexist, even in the same region, without significant contact between them – their economic strategies were too different.

74 Tovkailo 2005.

Figures

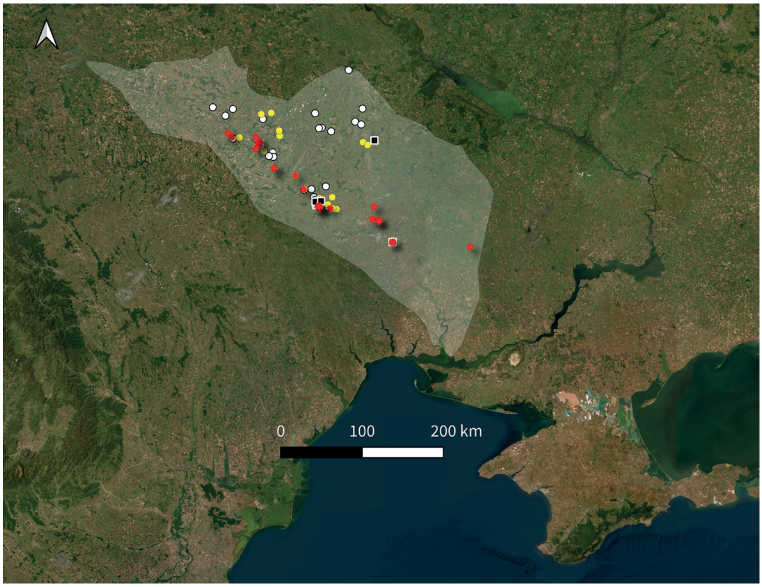

Figure 59 Definition of the region of study. Grey line encircles the catchment of the Southern Buh River. Red stars: para-Neolithic sites; dark squares: LBK sites and stray finds; yellow dots: Precucuteni sites and stray finds; empty dots: Trypillia B1 sites. MSB – Middle Southern Buh region, see fig. 60. Topo: ESRI. Mapping by the Author

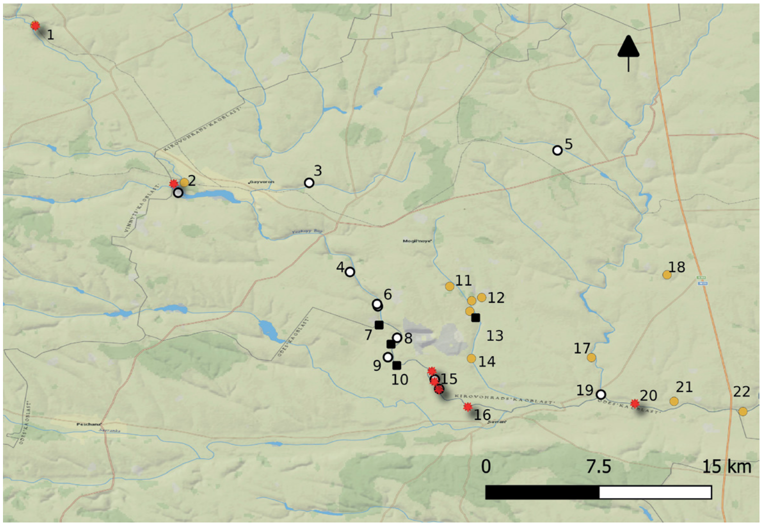

Figure 60 The sites of the Middle Southern Buh region, MSB in fig. 59. Topo: Stamen Terrain. Red stars: para-Neolithic sites; black squares: LBK settlements; yellow dots: Precucuteni – Early Trypillia sites; empty dots: Trypillia B1 sites. 1: Schurivtsi-Porih; 2: Haivoron, Haivoron-Polizhok; 3: Topoli; 4: Dovhyi Iar; 5: Mechyslavka; 6: Kozachyi Yar 1-2; 7: Syne Ozero; 8: Kamyane-Zavallia, Kamyane-Zavallia 1; 9: Shamrai; 10: Hnyla Skelia; 11: Mohylna 1; 12: Mohylna 2-5; 13: Zhakchyk 3; 14: Tashlyk; 15: Zavallia, Zhakchyk, Vovcha gatka, Berezivska HES; 16: Savran; 17: Sabatynivka 2; 18: Danylova Balka; 19: Sabatynivka 1; 20: Melnychna Krucha; 21: Hrenivka; 22: Krasnenke. Topo: Stamen Terrain. Mapping by the Author

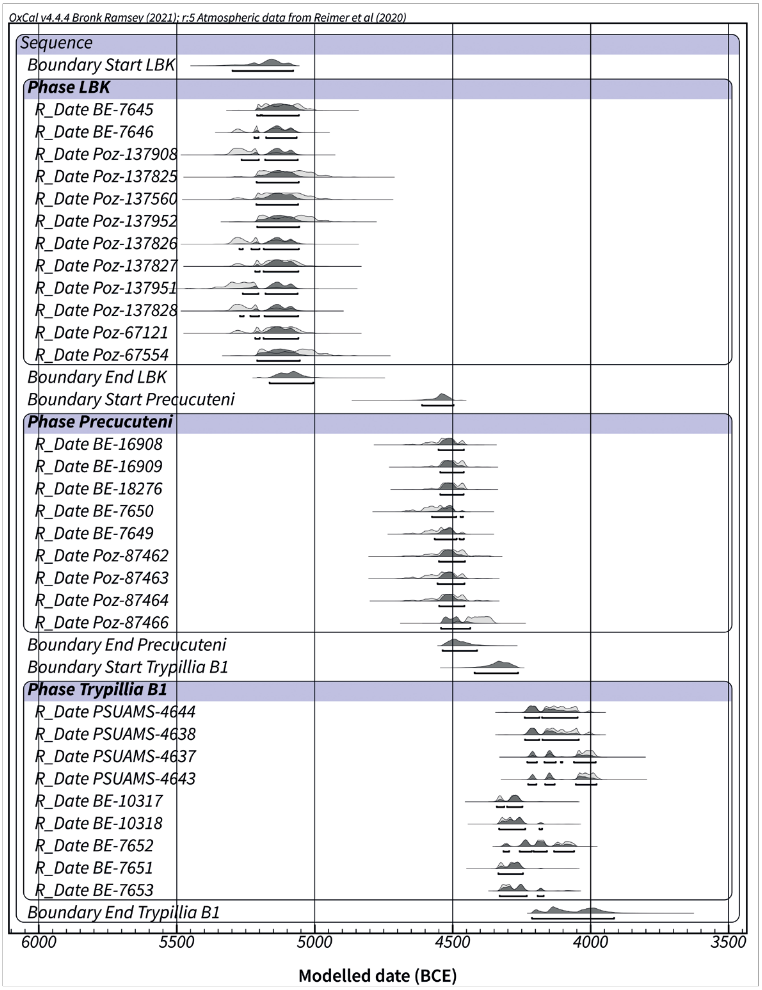

Figure 61 Modeled radiocarbon dates. The figure done by OxCal software with IntCal20 calibration curve of Reimer et al. 2020. Phase 1: LBK; 2: Precucuteni – Trypillia A; 3: Trypillia B1. For details on the calibrated dates, see Kiosak et al. 2021, **ST4-1**. Done in OxCal by the Author

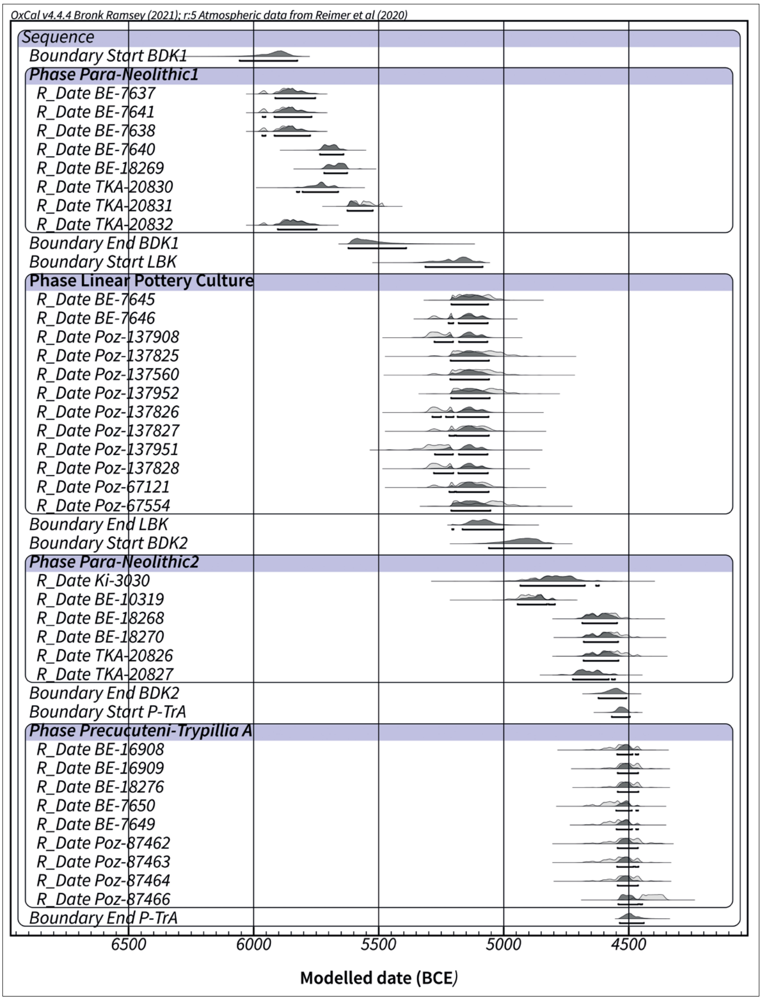

Figure 62 Southern Buh region. Radiocarbon dates modelled with sequential phases. BDK1: para-Neolithic, first temporal block; LBK: Linear Pottery Culture; BDK2: para-Neolithic, second temporal block; P-TrA: Precucuteni – Early Trypillia. Dates: **ST 4-1**. Code: **Model 4-2**. Done in OxCal by the Author

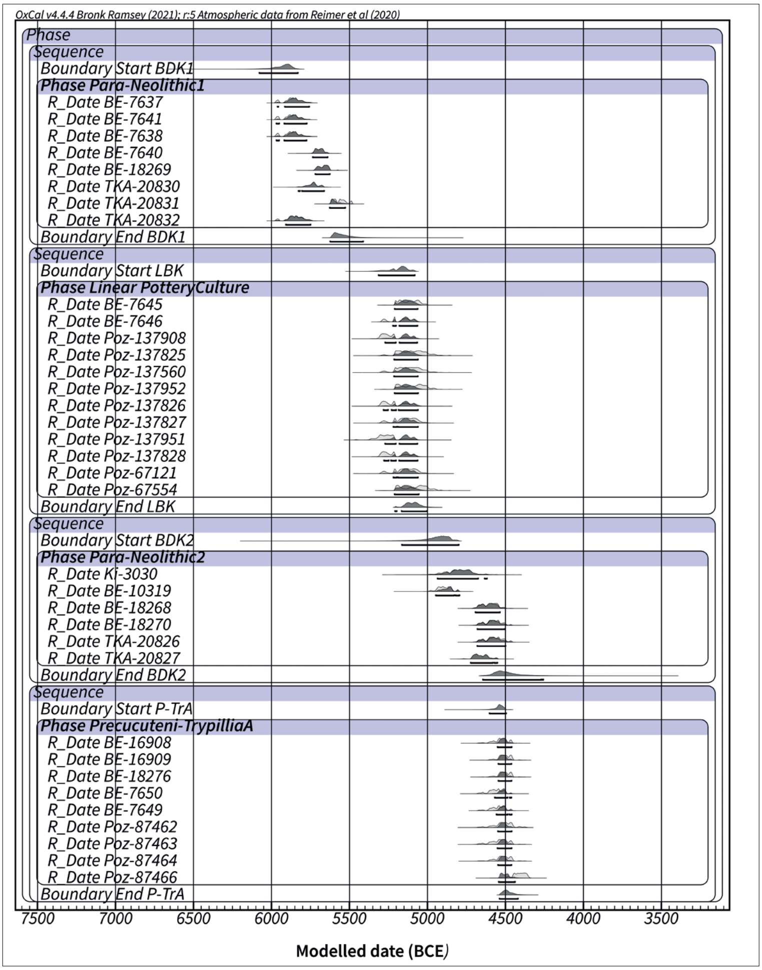

Figure 63 SBR. Radiocarbon dates modelled with overlapping phases. BDK1: para-Neolithic, first temporal block; LBK: Linear Pottery Culture; BDK2: para-Neolithic, second temporal block; P: Tr A – Precucuteni – Early Trypillia. Code: **Model 4-1**. Dates: **ST 4-1**. Done in OxCal by the Author

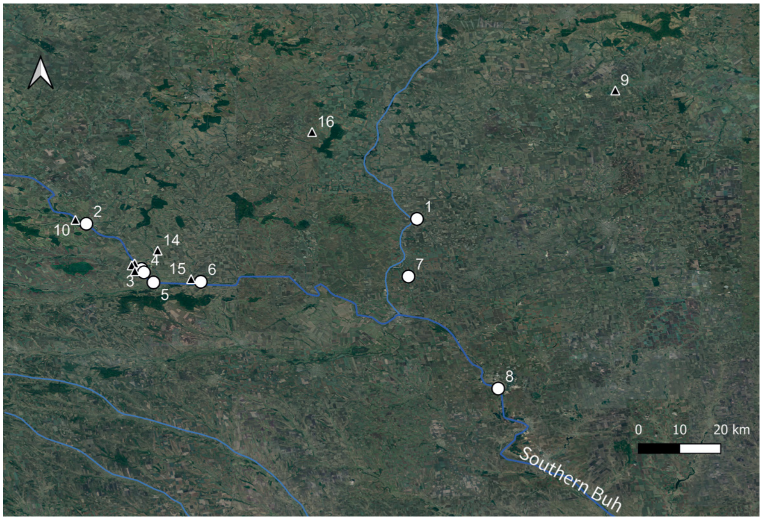

Figure 64 Sites which yielded information on Holocene soils in the Southern Buh valley. White dots: early farmers; black triangles: para-Neolithic sites. 1: Dobrianka 1-3; 2: Haivoron-Polizhok; 3: Zavallia; 4: Zhakchyk; 5: Savran; 6: Melnychna Krucha; 7: Mykolyna Broiaka; 8: Gard, Lidyna Balka; 9: Likareve; 10: Haivoron; 11: Kamyane-Zavallia 1; 12: Kamyane-Zavallia; 13: Shamrai; 14: Mohylna 3; 15: Sabatynivka 1; 16: Nebelivka. Topo: Google Earth. Mapping by the Author

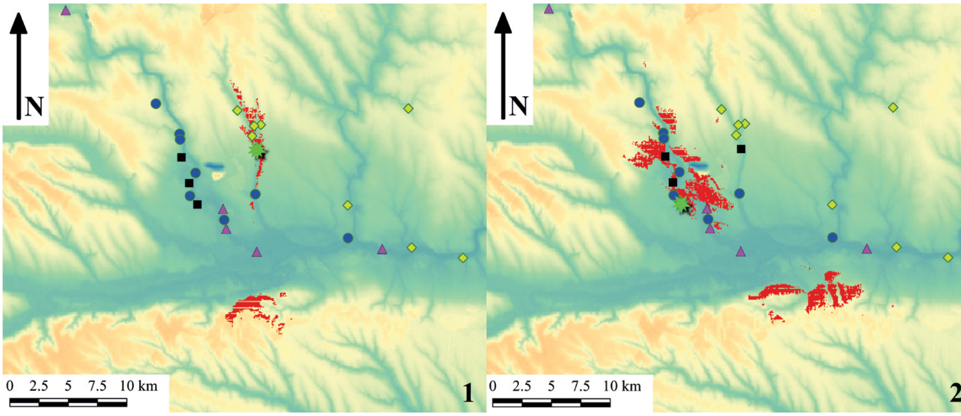

Figure 65 The viewshed analysis areas (red) of the Linear Pottery Culture sites in order to check for mutual visibility. LBK sites are marked with black squares, para-Neolithic sites are purple triangles, Trypillia A sites are marked with yellow rhombs, and Sabatynivka group sites are marked with blue circles. The observation points are marked with green star. 1: Zhakchyk III; 2: Hnyla Skelya. The viewshed of Hnyla Skelia (2) marks the 'core area' of LBK in the Southern Buh region. Topo: Natural Earth. Mapping by Simon Radchenko

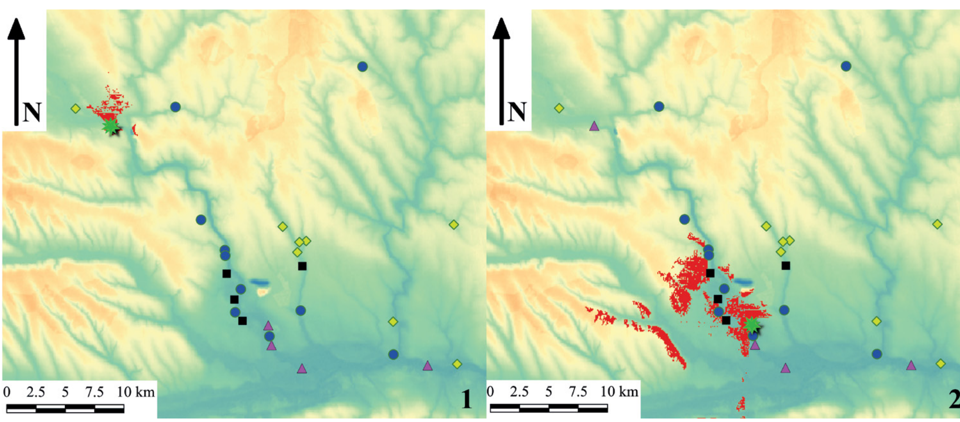

Figure 66 The viewshed analysis areas (red) of the para-Neolithic sites in order to check for mutual visibility. LBK sites are marked with black squares, para-Neolithic sites are purple triangles, Trypillia A sites are marked with yellow rhombs, and Sabatynivka group sites are marked with blue circles. The observation points are marked with green star. 1: Haivoron-Polizhok; 2: Zavallia. Note that even the para-Neolithic site with the highest visibility (2) has no mutual visibility with other para-Neolithic sites. Topo: Natural Earth. Mapping by Simon Radchenko

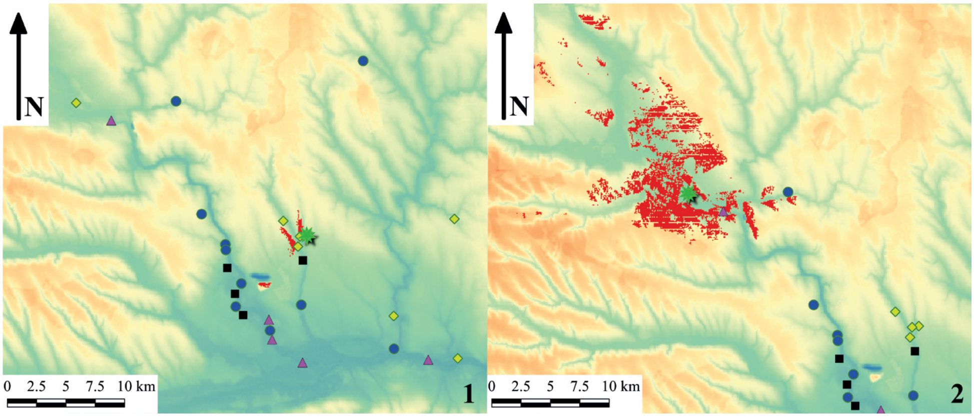

Figure 67 The viewshed analysis areas (red) of the Trypillia A sites in order to check for mutual visibility. LBK sites are marked with black squares, para-Neolithic sites are purple triangles, Trypillia A sites are marked with yellow rhombs, and Sabatynivka group sites are marked with blue circles. The observation points are marked with green star. 1: Mohylna III; 2: Haivoron. Topo: Natural Earth. Mapping by Simon Radchenko

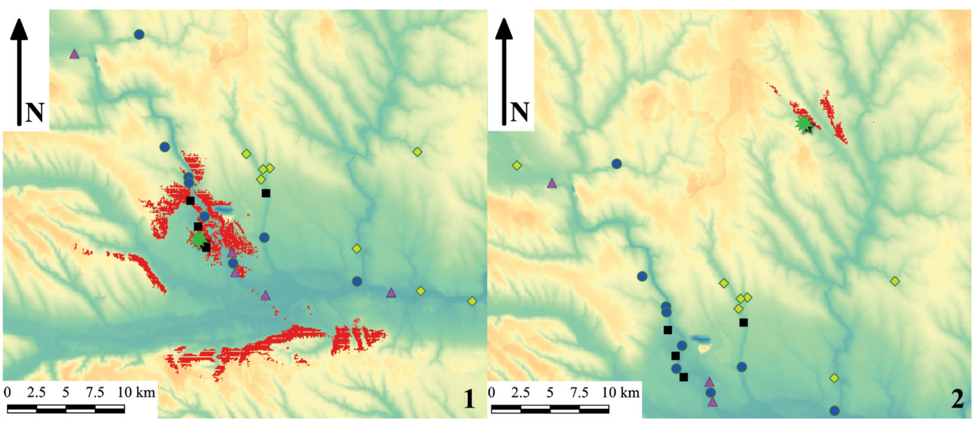

Figure 68 The viewshed analysis areas (red) of the Trypillia B sites in order to check for mutual visibility. LBK sites are marked with black squares, para-Neolithic sites are purple triangles, Trypillia A sites are marked with yellow rhombs, and Sabatynivka group sites are marked with blue circles. The observation points are marked with green star. 1: Shamrai; 2: Mechyslavka. Topo: Natural Earth. Mapping by Simon Radchenko

Supplementary Table

Table 4-1 Relevant dates for Southern Buh region divided into phases

Site Name	Provenance	Lab. Number	Date BP	SD	Cultural aspect	Material	CalBC (1 sigma)	CalBC (2 sigmas)	Reference	
BDK1										
Melnychna Krucha	SU2	BE-7637	6980	24	Unknown	Bone	5980-5900	5990-5880	Kiosak et al. 2021	
Melnychna Krucha	SU2	BE-7641	6986	24	Unknown	Bone	5872-5778	5888-5748	Kiosak et al. 2021	
Melnychna Krucha	SU2	BE-7638	6985	22	Unknown	Antler	5773-5724	5835-5714	Kiosak et al. 2021	
Melnychna Krucha	SU2	BE-7640	6812	24	Unknown	Bone	5762-5716	5806-5675	Kiosak et al. 2021	
Mykolyna Broiaka	House 1, 280 cm deep	BE-18269	6762	27	Savran?	Animal bone	5708-5631	5719-5625	Kiosak et al. subm	
Bazkiv Ostriv	vessel 1	TKA-20830	6855	30	Samchyntsi	pottery paste	5769-5707	5807-5666	Treated as unreliable by D.	Excl
Bazkiv Ostriv	vessel 22	TKA-20831	6625	25	Skybentsi	pottery paste	5613-5534	5621-5514	Haskevych et al. 2019.	Incl
Bazkiv Ostriv	vessel 21	TKA-20832	6970	25	Skybentsi	pottery paste	5891-5810	5972-5769	Treated as unreliable by D.	Incl
LBK										
Hnyla Skelia	pit 1	BE-7645	6163	23	Notenkopf LBK	Animal bone	4986-4858	5000-4848	Kiosak et al. 2021	
Hnyla Skelia	pit 1	BE-7646	6222	23	Notenkopf LBK	Animal bone	5000-4940	5041-4857	Kiosak et al. 2021	
Kamyane-Zavallia	F2003	Poz-137908	6260	40	Notenkopf LBK	T. monococcum	5305-5208	5315-5068	Moskal-del-Hoyo et al 2023	
Kamyane-Zavallia	F2003	Poz-137825	6150	50	Notenkopf LBK	T. monococcum	5206-5026	5215-4944	Moskal-del-Hoyo et al 2023	
Kamyane-Zavallia	F2006	Poz-137560	6170	50	Notenkopf LBK	T. monococcum	5207-5050	5295-4987	Moskal-del-Hoyo et al 2023	
Kamyane-Zavallia	F2006	Poz-137952	6140	40	Notenkopf LBK	Fallopia convolvulus	5206-5001	5211-4952	Moskal-del-Hoyo et al 2023	
Kamyane-Zavallia	F2008	Poz-137826	6240	40	Notenkopf LBK	Triticum sp.	5301-5078	5308-5059	Moskal-del-Hoyo et al 2023	
Kamyane-Zavallia	F2008	Poz-137827	6200	40	Notenkopf LBK	T. monococcum	5212-5065	5299-5030	Moskal-del-Hoyo et al 2023	
Kamyane-Zavallia	F2009	Poz-137951	6290	50	Notenkopf LBK	Triticum sp.	5311-5214	5370-5070	Moskal-del-Hoyo et al 2023	
Kamyane-Zavallia	F2009	Poz-137828	6250	40	Notenkopf LBK	T. monococcum	5304-5125	5370-5070	Moskal-del-Hoyo et al 2023	
Kamyane-Zavallia	pit 1	Poz-67121	6200	40	Notenkopf LBK	Animal bone	5218-5070	5295-5045	Kiosak, Salavert 2018	
Kamyane-Zavallia	pit 1	Poz-67554	6130	40	Notenkopf LBK	Animal bone	5206-4997	5211-4962	Kiosak, Salavert 2018	
BDK2										
Puhach-2	Cultural layer	Ki-3030	5920	60	Savran	Charcoal	4877-4717	4961-4618	Tovkailo 2014	
Melnychna Krucha	SU-R4	BE-10319	6008	21	Unknown	Bone	4880-4795	4930-4780	Kiosak et al. 2021	
Puhach-2	cultural layer	BE-18268	5750	26	Savran	animal bone	4656-4543	4686-4503	Kiosak et al. subm	
Mykolyna Broiaka	cultural layer	BE-18270	5731	26	Savran	animal bone	4647-4505	4678-4493	Kiosak et al. subm	
Shumyliv-Cherniatka		TKA-20826	5725	30	Savran	from the vessel	4608-4515	4683-4491	Haskevych et al. 2019.	
Shumyliv-Cherniatka		TKA-20827	5805	25	Savran	pottery paste of the	4709-4615	4723-4558	Haskevych et al. 2019.	
P-ET										
Mohylna-3	Soil section	TrA3	BE-16908	5699	26	animal bone	4549-4459	4607-4453	Kiosak et al. subm	
Mohylna-3	Soil section	TrA3	BE-16909	5679	27	animal bone	4539-4458	4599-4447	Kiosak et al. subm	
Sabatynivka-2		TrA3	BE-18276	5681	25	animal bone	4539-4458	4590-4447	Kiosak et al. subm	
Mohylna III	in the rubble of ploschadka	TrA3	BE-7650	5722	23	bone	4580-4501	4616-4466	Kiosak et al. 2021	
Mohylna V	pit 1	TrA3	BE-7649	5712	22	bone	4599-4523	4677-4493	Kiosak et al. 2021	
Hrebeniukiv Iar	pit, lowest level	TrA3	Poz-87462	5680	40	bone	4545-4453	4655-4369	Shatilo, 2021	
Hrebeniukiv Iar	pit, lower fill, upper layer	TrA3	Poz-87463	5700	35	bone, cattle	4587-4457	4671-4449	Shatilo, 2021	
Hrebeniukiv Iar	pit, lower fill, upper layer	TrA3	Poz-87464	5685	35	bone, cattle	4545-4455	4651-4406	Shatilo, 2021	
Hrebeniukiv Iar	pit, upper pit fill	TrA3	Poz-87466	5585	35	bone, cattle	4446-4363	4492-4347	Shatilo, 2021	
Cucuteni A - Trypillia B1										
Berezivska HES	Ber1	*CuA-TrB1*	PSUAMS-4644	5295	25	animal bone	4226-4049	437-3999	Harper et al. 2023	
Berezivska HES	Ber1	*CuA-TrB1*	PSUAMS-4638	5285	25	animal bone	4225-4046	4233-3994	Harper et al. 2023	
Berezivska HES	BerII	*CuA-TrB1*	PSUAMS-4637	5235	25	animal bone	4049-3984	4210-3964	Harper et al. 2023	
Berezivska HES	BerII	*CuA-TrB1*	PSUAMS-4643	5220	25	animal bone	4943-3983	4211-3964	Harper et al. 2023	
Berezivska HES		*CuA-TrB1*	BE-10317	5438	21	animal bone	4334.5-4259.5	4342.5-4249.5	Kiosak et al. 2020	
Berezivska HES		*CuA-TrB1*	BE-10318	5406	21	animal bone	4326.5-4248	4333.5-4175	Kiosak et al. 2020	
Kamyane-Zavallia 1		*CuA-TrB1*	BE-7652	5346	21	animal bone	4246.5-4065	4317.5-4052.5	Kiosak et al. 2020	
Kamyane-Zavallia 1		*CuA-TrB1*	BE-7651	5424	21	animal bone	4330-4255.5	4337-4246.5	Kiosak et al. 2020	
Shamrai		*CuA-TrB1*	BE-7653	5394	21	animal bone	4324.5-4241.5	4332.5-4169.5	Kiosak et al. 2020	

Models

Model 4-1 Overlapping phases for the Southern Buh region (SBR)

```
Plot()
  {
    Phase()
    {
      Sequence()
      {
        Boundary("Start BDK1");
        Phase("BDK1")
        {
          R_Date("BE-7637",6980,24);
          R_Date("BE-7641",6986,24);
          R_Date("BE-7638",6985,22);
          R_Date("BE-7640",6812,24);
          R_Date("BE-18269",6762,27);
          R_Date("TKA-20830",6855,30);
          R_Date("TKA-20831",6625,25);
          R_Date("TKA-20832",6970,25);
        };
        Boundary("BDK1");
      };
      Sequence()
      {
        Boundary("Start LBK");
        Phase("LBK")
        {
          R_Date("BE-7645",6163,23);
          R_Date("BE-7646",6222,23);
          R_Date("Poz-137908",6260,40);
          R_Date("Poz-137825",6150,50);
          R_Date("Poz-137560",6170,50);
          R_Date("Poz-137952",6140,40);
          R_Date("Poz-137826",6240,40);
          R_Date("Poz-137827",6200,40);
          R_Date("Poz-137951",6290,50);
          R_Date("Poz-137828",6250,40);
          R_Date("Poz-67121",6200,40);
          R_Date("Poz-67554",6130,40);
        };
        Boundary("End LBK");
      };
      Sequence()
      {
        Boundary("Start BDK2");
        Phase("BDK2")
        {
          R_Date("Ki-3030",5920,60);
```

```
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      R_Date("BE-18268",5750,26);
      R_Date("BE-18270",5731,26);
      R_Date("TKA-20826",5725,30);
      R_Date("TKA-20827",5805,25);
    };
    Boundary("End BDK2");
  };
  Sequence()
  {
    Boundary("Start Precucuteni");
    Phase("Precucuteni")
    {
      R_Date("BE-16908",5699,26);
      R_Date("BE-16909",5679,27);
      R_Date("BE-18276",5681,25);
      R_Date("BE-7650",5722,23);
      R_Date("BE-7649",5712,22);
      R_Date("Poz-87462",5680,40);
      R_Date("Poz-87463",5700,35);
      R_Date("Poz-87464",5685,35);
      R_Date("Poz-87466",5585,35);
    };
    Boundary("End Precucuteni");
  };
 };
};
```

Model 4-2 SBR with sequential phases

```
Plot()
  {
    Sequence()
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      Phase("BDK1")
      {
        R_Date("BE-7637",6980,24);
        R_Date("BE-7641",6986,24);
        R_Date("BE-7638",6985,22);
        R_Date("BE-7640",6812,24);
        R_Date("BE-18269",6762,27);
          R_Date("TKA-20830",6855,30);
          R_Date("TKA-20831",6625,25);
          R_Date("TKA-20832",6970,25);

      };
      Boundary("End BDK1");
      Boundary("Start LBK");
      Phase("LBK")
      {
        R_Date("BE-7645",6163,23);
        R_Date("BE-7646",6222,23);
        R_Date("Poz-137908",6260,40);
        R_Date("Poz-137825",6150,50);
        R_Date("Poz-137560",6170,50);
        R_Date("Poz-137952",6140,40);
        R_Date("Poz-137826",6240,40);
        R_Date("Poz-137827",6200,40);
        R_Date("Poz-137951",6290,50);
        R_Date("Poz-137828",6250,40);
        R_Date("Poz-67121",6200,40);
        R_Date("Poz-67554",6130,40);
      };
      Boundary("End LBK");
      Boundary("Start BDK2");
      Phase("BDK2")
      {
        R_Date("Ki-3030",5920,60);
        R_Date("BE-10319",6008,21);
        R_Date("BE-18268",5750,26);
        R_Date("BE-18270",5731,26);
        R_Date("TKA-20826",5725,30);
        R_Date("TKA-20827",5805,25);
      };
      Boundary("End BDK2");
      Boundary("Start Precucuteni");
      Phase("Precucuteni")
      {
```

```
      R_Date("BE-16908",5699,26);
      R_Date("BE-16909",5679,27);
      R_Date("BE-18276",5681,25);
      R_Date("BE-7650",5722,23);
      R_Date("BE-7649",5712,22);
        R_Date("Poz-87462",5680,40);
        R_Date("Poz-87463",5700,35);
        R_Date("Poz-87464",5685,35);
        R_Date("Poz-87466",5585,35);

    };
    Boundary("End Precucuteni");
  };
};
```