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The Building Blocks of Circular Economies: Rethinking Prehistoric Turf Architecture Through Archaeological and Architectural Analysis

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Abstract: Research into prehistoric buildings in northwest Europe has identified the ubiquitous use of turf. The study first introduces direct and proxy evidence for the material's detection in the field, then analyses individual case studies to demonstrate how this locally available and renewable material shaped buildings and building practices. Turf, grown and sourced on or near a site, ties buildings to their landscape, while creating flexible shells that can shift as needed, metamorphosing built space and volume accordingly. Turf's capacity to then compost and regrow embeds its buildings into a prehistoric circular economy that interweaves dwellings, people, animals, plants, soils, and nutrients into a holistic understanding of a "curated" rather than a "built" environment – an architecture borrowed from the soil to which it can return. The characteristics of turf blocks as a malleable and arguably metamorphosing building material call for a rethink of turf architecture, not resulting in static products but in ongoing circular processes. This new concept operates within an extended lifecycle of houses, not as in traditional approaches from birth (built) to death (abandoned), but within a cyclical, cradle-to-cradle approach. An experimental training project now translates this prehistoric cyclical model into modern sustainable turf building practice to demonstrate its potential for positive climate action today.

Keywords: prehistory, turf architecture, micromorphology, circular economies, climate action

1 An Archaeology of Turf

Turf has been a common earth-based building material in the northern hemisphere, with versatile uses for thousands of years (Parkin & Adderley, 2017). Simple turf boundary walls date back to the Iron Age in Jutland (Kristensen, 2020, pp. 19–21; Løvshal & Holst, 2014) or to early medieval land use traditions in Iceland (Einarsson, 2002). The oldest use of turf for building houses and farmsteads arguably dates back to the first settlers in the Early Neolithic as for example recorded in Scotland (Knap of Howar, Orkney: Loveday, 2006; Romankiewicz, 2019). In Denmark, evidence for turf houses is known from the Bronze Age (e.g. Boas, 1991, 1993). In North-Germany and the northern Netherlands, remains of turf buildings and retaining walls

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are well preserved within settlement mounds starting in the Roman Iron Age and continuing into the migration period (e.g. Feddersen Wierde: Haarnagel, 1979; Struckmeyer & Hauke, 2020; Wurt Hessens: Siegmüller, 2010; Dutch and Danish examples summarised in Snyder, Russell, Romankiewicz, & Beckett, 2023 and in Russell, Beckett, Romankiewicz, Snyder, & Lin, in press). A recent discovery of a Grubenhaus at Remels, near Leer in German Ostfriesland, dating to the ninth century AD, links turf-walled architecture to semi-subterranean construction (Kanczok, 2008, pp. 141–142). In the Dutch province of Fryslân, turf was used in hydraulic engineering to line wells or cisterns or was employed in harbour installations (Nicolay, 2010). Turf has also been used for funerary architecture, described for Neolithic long barrows in Britain (McFadyen, 2006a,b), Bronze Age burial mounds in Jutland, and for Viking tumuli such as the impressive mounds of Gamla Uppsala in Sweden or on the Isle of Man (Holst & Rasmussen, 2013; Wilson, 2008). The Romans built with turf blocks at forts and frontier installations (Romankiewicz et al., 2022; Russell et al., 2022). Many of these massive ramparts, or the frontier line formed by the Antonine Wall in Scotland, are still substantial upstanding turf constructions to the day. However, other ancient turf buildings, especially those in more ephemeral domestic contexts, consisting essentially of topsoil and roots, have disintegrated or have been ploughed out. Very few turf houses are still upstanding to any significant height (Reid, 2021; for Iceland e.g. Stefánsson, 2019a; compare Vésteinsson, McGovern, & Keller, 2002).

1.1 Upstanding Remains of Turf Houses

One exception to this, and the often-cited example for well-preserved upstanding turf houses, is the Icelandic tradition. The last surviving upstanding structures generally date to the eighteenth and ninteenth century, such as at Hólar and Glaumbær in the northwest. Only a few original houses are still upstanding without significant rebuilding (Figure 1). While most of these houses are preserved as living museums, only parts of their walls still contain the 200–300 years old original turf blocks. Many wall elements have seen repeated repair, especially in those parts which are most exposed to rainwater draining off the roofs or which are threatened by wind-drying and erosion. Freshly cut turf "bricks" were used to replace the original bricks or blocks (Figure 2; Stefánsson, 2019b, pp. 14–15). The flexibility and malleability of turf walls, and of the individual turf blocks, allowed such ad hoc, *in situ* repairs without compromising the building's overall structural integrity. Older turf buildings, like Viking longhouses or the medieval and post-medieval turf houses from Scotland survive only as low banks, in areas where they have escaped the plough (e.g. James, 2009; Strachan, Sneddon, & Tipping, 2019). The upstanding structures that we associate with them today are full-scale reconstructions (e.g. Scotland: Newtonmore Highland Folk Museum, Noble, 1983; Iceland: Þjóðveldisbærinn Viking Farm Stöng or BergÞórshvoll reconstruction at Eiríksstaðir).

Archaeological evidence of original turf walled buildings, dating to prehistoric or early medieval periods, remains ephemeral. The best-preserved examples are known from wet- and marshland sites, within the settlement mound tradition known as terps or Wurten in the southern North Sea region, like the sites cited above. Subsequent settlements have gradually risen above ground level by rebuilding of farmsteads, superseding each other on the same site (e.g. Nieuwhof, 2015). Contrary to the concept of shifting settlements prevailing in recent literature, discussed in German as "Wandersiedlungen," these buildings and settlements made from turf remained within one location (for shifting settlement models from the Bronze Age to Early Medieval periods see e.g. Bradley, Haselgrove, Vander Linden, & Webley, 2015, pp. 213–260; Brück, 1999; Crone et al., 2018; Gerritsen, 2003; Halliday, 2021; Hamelow, 2002, pp. 100–124; Moore, 2003, pp. 221–222; Schreg, 2012; but compare Arnoldussen, 2008). On the terps or Wurten, rooms were filled in and walls of previous buildings levelled off to provide a platform for subsequent ones (Figure 3; Postma, 2015, pp. 33–39; e.g. Olsdorf, northern Germany, see Schmid, 1994, Appendix pp. 231–267). In Iceland, while it seems that byres were built separately and used only within a single phase then relocated around the homefield, the turf houses were retained, reused, and rebuilt on the same spot, some over several hundreds of years (Berson, 2002, p. 58). Although the terp tradition leaves wall stumps surviving, these have not been systematically analysed with geoarchaeological methods to confirm the details of their construction. Existing geoarchaeological research either analysed cores from boreholes (Huisman, 2019; Nicolay, 2018) or concentrated on platform and floor formations rather than the construction of the house walls (Nicolay, 2010).

Figure 1: Turf houses surviving in the landscape, September 2022, Skagafjörður municipality, northwest Iceland. Top: Tyrfingsstaðir; bottom: Storu-Akrar. Photographs: Tanja Romankiewicz.

In Scotland, the uplands preserve remains of buildings as low banks of soil, such as the elongated Pitcarmick-type buildings dated to the early medieval period (e.g. at Pitcarmick: Carver et al., 2013; at Lair: Strachan et al., 2019). This visibility finds equivalents in upland roundhouses, the so-called hut-circles, dating to the Bronze Age and on occasion to the Iron Age (e.g. at Pitcarmick: Carver et al., 2013; at Dalrulzion: Rideout, 1996; at Lairg: McCullagh & Tipping, 1998). The silty nature of these banks is taken generally as an indicator for original turf walls; however, it is rare that individual turf blocks can be identified from macroscopic remains in the field (for a few examples see Romankiewicz, 2019). Although the Scottish upland areas have typically seen less intensive and invasive cultivation than the lowlands where modern deep ploughing has removed most upstanding remains, preservation is often still compromised (Halliday, 2021). A variety of homogenising factors render it difficult to distinguish individual turf blocks and wall elements from floor deposits or later infill. Bioturbation has been identified as having the acutest impact, but soil acidity levels are also contributing

Figure 2: Replacement of individual turf blocks as ad hoc, *in situ* replacements, Skagafjörður area, Iceland. Top: main farm buildings at Glaumbær Museum; bottom: multi-phased wall repairs of an outbuilding at Tyrfyngsstaðir. Photographs: Tanja Romankiewicz.

to dispersion of the fine fraction and free minerals across layers, accelerating homogenising effects. These processes are active together with the redistribution or leaching of iron or other minerogenic components (Reid, 2021, pp. 53, 56; compare Milek & French, 2007, pp. 324–325). As Reid's study has shown, integrated geoarchaeological analyses are needed to understand these stressors of preservation conditions. These should routinely comprise micromorphology paired with geochemical analysis, especially on soil acidity levels and magnetic susceptibility (Reid, 2021, p. 57).

Even if preservation at macroscale is poor, these same methods at microscale can be used to identify and confirm if turf architecture was present. This applies to upland as well as lowland settings. Micromorphology in particular offers the potential to further our understanding of the specific use of turf in a construction with rewarding results not just to confirm turf, but also to characterise its soil and vegetation layers (Huisman & Milek, 2017). This can then aid with characterising source locations and material curation, as well as

Figure 3: Section through the terp at Tuinsterwierde, near Leens, northern Netherlands, excavated by Albert Egges van Giffen 1939. © Rijksuniversiteit Groningen, Groninger Instituut voor Archeologie/© University of Groningen, Groningen Institute of Archaeology. CC-BY-NC 4.0.

identifying different construction processes. Recent results from well-preserved Roman turf ramparts at Vindolanda or the Antonine Wall have demonstrated the full potential of this geoarchaeological method (Figure 4; Romankiewicz et al., 2022; Russell et al., 2022). How best to combine these results with organic chemistry and microbiology, including sedaDNA, is currently explored by a team from the University of Edinburgh and Teesside University led by the author. Only a few prehistoric and early medieval sites have seen a suite of geoarchaeological study (e.g. Romankiewicz, Bradley & Clarke, 2020a). This is perhaps because of lack of awareness of the potential of micromorphological analysis or funding and programming issues may have hindered further analysis (Strachan et al., 2019, p. 56).

1.2 Archaeological Remains of Turf Walls Below Ground

Below-ground evidence of turf buildings may be much more ubiquitous than a superficial glance at the prehistoric record suggests (Romankiewicz, 2019). The Roman case studies have shown that where turf blocks survive below the ploughsoil or below layers of bioturbation, these are often well preserved and recognisable in section by their intact soil stratification. Layers of lighter subsoil and darker topsoil, and sometimes even with the black stripe of the decayed vegetation can be discerned (Russell et al., in press, pp. 869–870). Turf blocks can also be recorded in plan, especially where these were cut from different subsoils, as recent excavations demonstrated for the eastern section of the Antonine Wall in Scotland (Romankiewicz et al., 2022). At the clay-rich terp site of Wurt Hessens, blocks stood out from the surrounding topsoil after a period of drying and spraying (Siegmüller, 2010, p. 34).

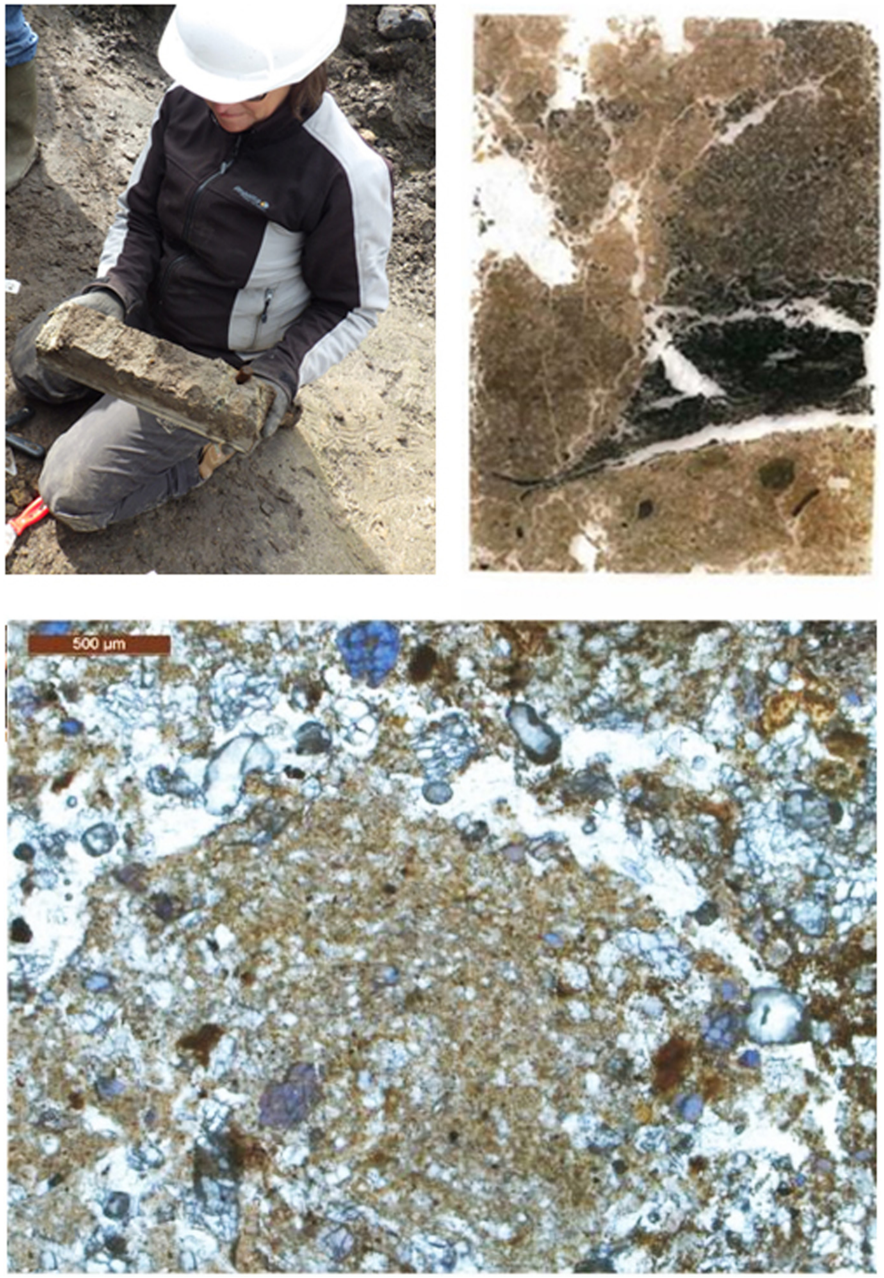

Figure 4: Details of micromorphological samples from Vindolanda Roman Fort, Northumberland, Northern England: in the field, at 1:1 resolution and under the microscope. Top left: sampling Period III rampart (Photograph: Ben Russell); top right: joint of three inverted turf blocks, with black O horizon (vegetation) and grey-brown A horizon (topsoil) against lighter subsoil of other blocks; bottom: articulated soil lens in centre (turf off-cut) surrounded by loose soil (micrograph photographs: Tom Gardner).

Preservation of turf blocks is naturally best in anaerobic conditions (Russell et al., 2022); however, a recent case study at Old Kinord, Aberdeenshire, demonstrated the benefits of applying micromorphological analysis even to ephemeral remains in dryland settings (Romankiewicz et al., 2020a). This identified the former presence of quite substantial turf-walled architecture from several building phases as well as the use of turf in the form of a carpet, to counteract floor erosion. Where individual turf blocks could still be made out by their higher iron content compared to the surrounding soil, these red blocks were targeted directly for thin section sampling and geoarchaeological analysis (Banerjea, 2017; Banerjea & Morandi, 2018). Without such conditions, it can be harder to distinguish turf walls from other buried soils during excavation and therefore to identify areas for sampling. Cut from the same topsoil that was likely used to infill abandoned buildings or that still covers the prehistoric house today, it is difficult to separate ancient turf from modern soils. Careful excavation, removing the modern turf using trowels instead of spades has been trialled to identify such boundaries. However, such techniques cannot be sustained on every site with the potential for turf walls. Such excavations are very labour-intensive or dense modern vegetation hinders successful results (Jonathan Wordsworth, pers. comm.). In other cases, evidence has deteriorated so far, through truncation or homogenisation, that direct remains are too ephemeral or simply not extant anymore (Reid, 2021). Here it is important to consider proxy evidence for turf constructions. Decayed turf walls are often brought forward as the best plausible alternative in the absence of other structural evidence for outer walls, but this still needs to be positively confirmed (Romankiewicz, 2019).

2 Turf as a Building Material

The properties of turf and the associated characteristics that it passes onto its architectural and archaeological record are defined by the concerted play of its two main material components: minerogenic soil and organic fibres. Its flexibility and malleability also depend on its moisture content.

2.1 Turf “Recipes”

A turf block consists of topsoil on which a vegetation carpet has grown, and often of parts of the underlying subsoil. This vegetation is typically of grass, but blocks with other plants could have been used (Russell et al., 2022, p. 199). Grass roots are thin and fragile, but can create a dense mat; other plants have thicker and longer but fewer roots with signs of lignification. These form much looser mats and can be less flexible. This mix of minerogenic soil and organic plants places turf blocks amongst other earthen building materials containing fibres, such as mudbricks and cob mixes (Snyder et al., 2023, p. 138). The latter are, however, deliberately mixed following specific recipes, some drier, some wetter, and with varying quantities of clay, silt, and sand, plus the addition of fibres (Russell et al., in press). In this sense, a turf block is a mudbrick prefabricated by nature, with its “recipe” dependent on the subsoil and topsoil conditions of a particular spot, and on the local growing conditions for its vegetation.

The expertise in procuring turf for building lies therefore not in the mixing and material preparation, but in selecting the right source location for a building task (Ágústsson, 1998[1981], p. 51; compare Milek, 2012, pp. 121–123). This builds on a deep understanding of the complexities of the underlying geology, the wider landscape situation, a site’s hydrology and climatic conditions, and the properties of its particular vegetation (Sigurðardóttir, 2011; see Snyder et al., 2023, p. 139). Turf architecture seems best informed by a long-standing experience of building with material from one particular setting, or by extensive training using different turfs derived from different locations (Postma, 2015; Stefánsson, 2019a; Walker, 2006).

The use of turf in their military architecture projects along the frontiers of the empire provided the Roman army with such breadth of experience. Some knowledge was derived from existing skills by auxiliary units, but was also continuously developing (Russell et al., 2022, in press). At the Antonine Wall for example, different turf materials were chosen for core and facings, the so-called cheeks. The sandy, clay-rich cheek material optimised evaporation and minimised moisture build-up in the core (Romankiewicz et al., 2022). Core and cheek were also keyed together at a 45° angle, presumably to avoid shearing; evidence that has also been recorded at High Rochester (Romankiewicz et al., 2022, p. 116, Illus 5). Further comparison with Roman turf building at Vindolanda shows even more variation in practice, but all seemingly with a trajectory towards sounder and longer-lasting constructions (Russell et al., in press). Our findings suggest that the Roman answer to differences in vegetation and soil conditions was to explore a wider area for suitable material, refine construction methods and accept an increase in transportation cost and labour in order to build with turf blocks best suited for the task. For prehistoric settlements, analysis is still outstanding; initial evidence suggests that material was sourced immediately on site (see below).

2.2 Turf's Temporal Component

The turf blocks' structural performance also depends on a temporal component, the maturity of the grassland, the season of cutting, and the wetness or dryness of the soil in the previous weeks and days, down to the very hour of the cut (Ágústsson, 1998[1981], p. 51). A turf cut under a hot sun will have very different properties from one harvested in pouring rain. Ambient temperature, relative humidity, and the soil's drying rate in direct sunlight on the days of cutting, curing, and building influence block procurement. Even the tempo of building, whether cutting for direct use or procuring blocks first by stacking and drying can influence a block's structural success (compare Ágústsson, 1998[1981], p. 51). A successful turf builder does not only need to know where to cut, but also when.

A turf builder therefore needs to be aware of all these aspects and balance these in light of the construction they want to achieve. They need to negotiate with every turf block about its role in the construction process and its performance within the built element. Building with turf is a dialogue with the material, and only if architects and builders make efforts to understand turf's language – and listen to what it has to "say" – are they able to succeed in building with it. Similarly, the archaeologists who excavate turf architecture will have to learn turf's language to be able to identify, characterise, analyse, and interpret its remains. Turf leads, we follow.

2.3 Block Dimensions

The turf builder can influence a turf wall's performance by choosing the size and thickness of the blocks they are cutting, and their shape. Icelandic turf building traditions comprise a large variety of blocks with different shapes and side angles created for specific tasks, cut by using different tools, and adjusted to the properties of the turf (Ágústsson, 1998[1981], p. 51; Sigurðardóttir, 2011; Stefánsson, 2019a). The only surviving Roman turf building manual gives quite specific block dimensions (Russell et al., 2022, p. 201; Snyder et al., 2023, p. 140); however, analysis of a multi-period rampart at the fort of Vindolanda showed notable variation between blocks, cut by different auxiliary units (Russell et al., 2022, p. 202). It seems likely that units had their preferred block shapes and, like in Iceland, these related to their cutting tools and building methods (Russell et al., 2022, pp. 202–204, Table 5).

Prehistoric turf block shapes and dimensions are harder to determine. Excavations of Iron Age roundhouses in Scotland with evidence for collapsed turf walls, such as at Old Kinord or Birnie (Moray), or recently at Gairloch (Highlands) indicate that small, chunky blocks were used, around 15–20 cm on average, seemingly cut wedge-shaped (Hunter, 2009; Romankiewicz, 2019; Romankiewicz et al., 2020a; Tom Gardner, pers. comm.). Blocks at the Late Roman Iron Age Wurt Hessens in northern Germany were similarly blocky, but had been cut in squares rather than wedges. With an average of 30–40 cm, these were also larger than the Scottish prehistoric blocks (Siegmüller, 2010, Beilage 2). Evidence from the early medieval terps in the northern Netherlands shows that long, thin blocks had been cut up to 1 m in length (Nicolay, 2010, pp. 94–96, Figure 3.4–3.6; Postma, 2015, pp. 38, 53, 77–78). At the early medieval elongated houses at Lair, thin blocks, so-called divots, seem to have been used; their length could not be established (Strachan et al., 2019, p. 120). A recent trial construction using turf blocks cut from mature grazing pastures at Comrie Croft in Perthshire succeeded in cutting and moving strips up to 1.1 m in length without ripping or breakage (https://www.thinglink.com/media/1500157031665893378). This risk of ripping and therefore spoiling a block could be one reason for limiting block dimensions, especially when blocks are picked up at their ends. Ripping can be avoided by lifting them grass-side up with a pronged fork and carrying the blocks with the fork supporting the block in the centre part. Carrying blocks by hand is best done grass-side down, because this uses the matted vegetation mesh to its advantage to retain a block's integrity. Very long strips or those with little fibres can be carried on a board or stretcher (Romankiewicz et al., 2022, p. 131).

The thickness of turf blocks depends on the depth of the soil; a block will naturally split off where the root matting stops, typically at the interface between the humic topsoil and the less nutrient-rich subsoil. This can be likened to "skinning the earth," as dense but thin root matting can often be peeled off from the subsoil, once laterally cut according to block dimensions (Becky Little, Tom Morton pers. comm.). Such a peeling technique would not require an undercut and may have been used in Neolithic turf cutting processes, when metal blades were not yet available. Sharp wooden spades or bone blades may have sufficed for the vertical cuts (compare McFadyen, 2006b for thoughts on Neolithic turf building practices). Sickle-shaped flint tools with a blade curvature similar to the Icelandic steel turf-sickles (*torflía*) have been proposed as turf cutting tools, but practicalities remain to be demonstrated (Postma, 2015, pp. 105, Afb. 105, 106; compare Evans 1897, pp. 326–327, 354–359). The Icelandic torflía creates lozenge-shaped blocks with tapered ends as it cuts down at an angle from the surface and along in one sweeping motion. It therefore also does not require an undercut to separate blocks.

The Scottish evidence, both archaeologically and from modern field experiments, suggests that turf blocks are usually no more than 10–12 cm deep; but thinner if developed on poorer upland soils, well-draining gravel, or leached podsols (Strachan et al., 2019, p. 119). The length of a turf block therefore depends also on its soil conditions. Blocks with deep topsoil horizons will have to be cut to smaller sizes; thinner blocks can be longer, especially where good root matting has developed on wetter soils (Strachan et al., 2019, p. 119). This relationship between block size and soil is determined by the maximum weight of ca. 20–25 kg that one person can lift and carry comfortably and repeatedly over a prolonged period (Snyder et al., 2023, p. 141).

In Iceland, turf blocks have traditionally been cut from wet boglands beyond the pastoral zone around the farmsteads, where thick root mats developed. Under these conditions, the same location can be cut twice; once with the vegetation on top, and a second time at a lower level with root matting only (Milek, 2012, pp. 121–123; compare Russell et al., 2022, pp. 201–202 and Table 2 for evidence in a Roman context). Given the light, silty soils in Iceland derived from volcanic ashes, the structural capacity of Icelandic turf walls often relies on the dense root matting for stability. In heavier soils where clay particles serve as binders, the minerogenic components add to the block's cohesion with less reliance on root matting. At the Antonine Wall for example, sandy/clay-rich blocks had been specifically selected for the front courses of the rampart with seemingly a lowly developed root and plant matting (Romankiewicz et al., 2022, pp. 122–123, Illus 5, 6, 7).

2.4 Negotiations in Turf

The turf properties present the conditions to which a builder has to adjust their processes and these will shape the architecture created from it. Despite this, turf is not unchangeable and static; it is spongy and flexible, can be cut and squeezed, and thus "persuaded" to take on its required tasks within a construction. It is for the builder to negotiate this "material collaboration" and to realise when turf has reached its limits of flexibility, its limits of cooperation. At this stage, the turf construction will develop its own dynamics, and bring down the construction because its needs have not been listened to sufficiently (Postma, 2015, pp. 271–291). If treated according to its properties and capabilities, turf can outshine other earthen materials with its intricate striped appearance of layered soil horizons and vegetation and its ability to regrow *in situ*. This can produce vertical meadows for a living-building experience and add to the strength of a wall by interlocking the blocks externally against erosion (Ágústsson, 1998[1981], p. 52). Turf walls can also absorb or release moisture and buffer pressure and structural movement as currently investigated by the Earthen Empire project (Lin, Beckett, Romankiewicz, Snyder, & Russell, 2023).

Section 3 of this study gives an overview of the different ways of how ephemeral turf architecture can be identified from below-ground evidence in the field. This ranges from recognising proxy evidence as indicators

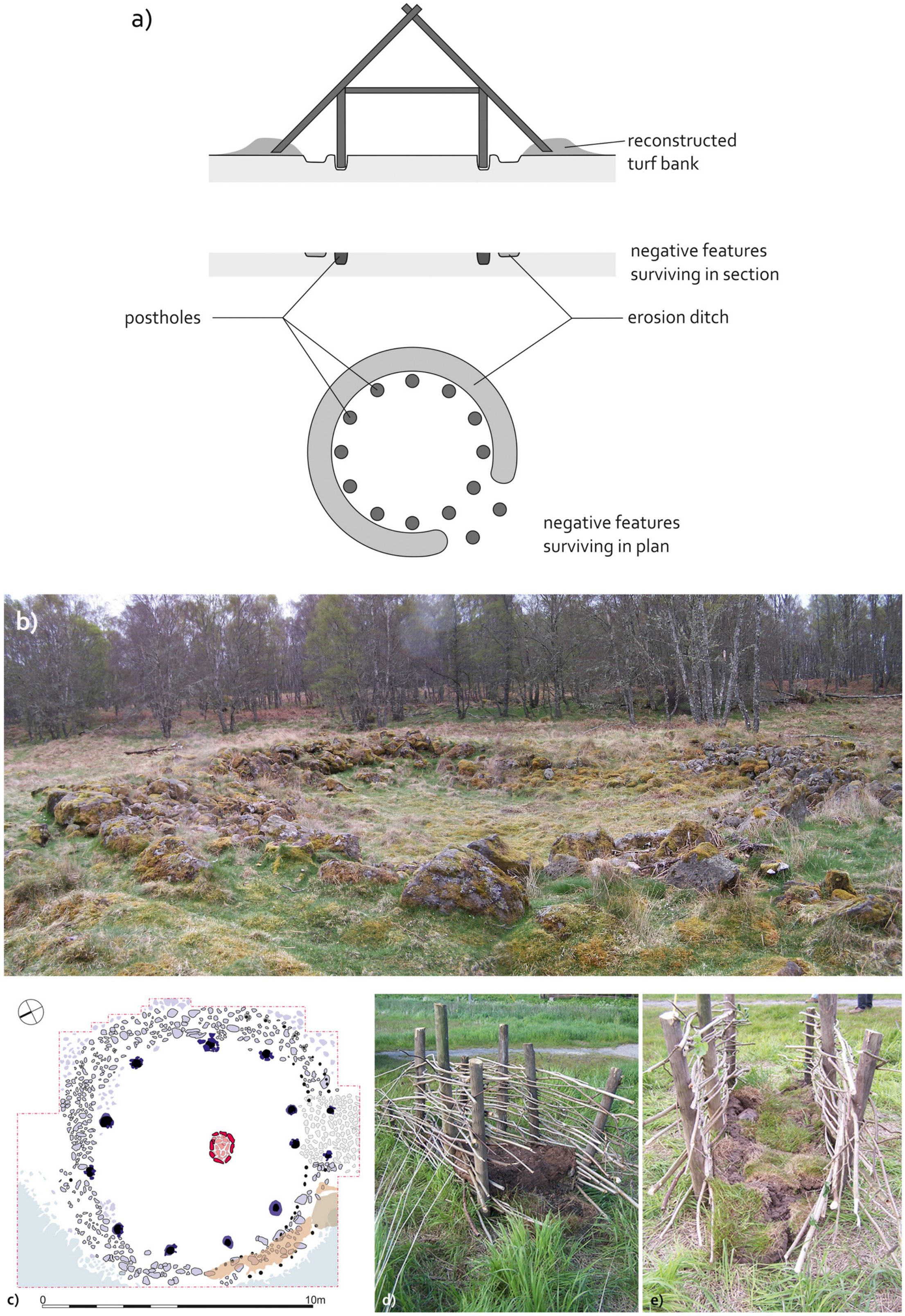

Figure 5: Proxy evidence for turf architecture: (a) schematic reconstruction of turf banks that appear as a blank area on truncated sites. Drawing: Tanja Romankiewicz after Cook & Dunbar, 2008, Illus 195; (b) substantial stone walls at the Old Kinord roundhouse site, Aberdeenshire, Northeast Scotland, shown to have supported an upper turf wall. Photograph: Tanja Romankiewicz; (c) gravel spread and sediment residue between concentric rows of stakeholes of a roundhouse at Green Knowe, Peeblesshire, southern Scotland, interpreted as a turf wall within wattle formwork (Drawing: Tanja Romankiewicz after Feachem, 1963, Figure 3); (d) and (e) turf and wattle frame trial reconstruction at Errol, Perthshire, informed by the Green Knowe evidence (Photographs: Tanja Romankiewicz).

of turf architecture to a short review of recent results from the author's prehistoric case studies. After this technical discussion, the study moves to a conceptual contextualisation of turf architecture within wider circular economic practices. It presents an initial discussion on how this cyclical building with turf is embedded in dynamic architectural and agricultural practices. The author's focus here remains on Scotland, while work on the wider northern European contextualisation is still underway.

3 Turf Detectives in the Field

Over the years of excavating turf structures and analysing records of possible prehistoric turf buildings, the author has identified a series of direct and proxy indicators for the existence of turf walls even if primary, articulated turf wall evidence is not preserved. If sufficient original material survives, this macroscopic evidence is then best targeted by geoarchaeological sampling to confirm the evidence for turf at microscopic scale (Huisman & Milek, 2017).

3.1 Proxy Evidence 1: The Gap

For some sites, the disintegration of the turf walls has advanced so far that positive evidence cannot be identified anymore. However, the negative evidence of a gap between a floor surface and an outer ground surface can be recognised (for example at Hemmed Church, House 1, Denmark: Boas, 1991, Figure 2, p. 82; 1993, p. 120). Even where no floor surfaces survive to demarcate outer walls, the lack of any structural evidence for an outer wall could be taken to imply the former presence of a turf wall (Figure 5a; compare Cook & Dunbar, 2008, Figure 195). This is, of course, the weakest argument for the former presence of turf architecture. Without any remains of articulated turf blocks, geoarchaeological methods can also not be called to aid identification.

3.2 Proxy Evidence 2: Stone Footings

Geotechnical analysis of turf walls suggests that introducing a drainage barrier that breaks the capillary suction would be beneficial for good and prolonged structural performance (Romankiewicz, Milek, Beckett, Russell, & Snyder, 2020b, pp. 126–128; compare Lin et al., 2023). This can be solved by a gravel course, but more effective would be a stone footing 2–3 courses high, that also raises the turf wall above the zone affected by splashing rain. This is now recommended practice in Iceland, although historical evidence suggests that walls used to be built directly on the ground. Only occasionally, low walls of small stones were used, sometimes interlaced with thin turf strips as a form of earthen mortar (e.g. settlement period house at Eiríksstaðir: Ólafsson & Traustadóttir, 1998, pp. 15, 17; general discussion in Romankiewicz, et al., 2020b, pp. 125–129).

The best-preserved and most sophisticated example for such a stone footing is likely to be the stone base underneath the Antonine Wall (Romankiewicz et al., 2022, pp. 108–114). In areas of intense modern ploughing, it is this neatly laid stone base with its kerbs on either side that allowed tracing the course of the Wall in the field even where the turf superstructure had been lost. Prehistoric stone bases can be similarly sophisticated and similarly massive in their extent. Such stone footings can in fact be so substantial that they have been interpreted as evidence of stone-walled houses, not considering an upper turf wall. These assumptions resulted in reconstructions of relatively low wall heights directly supporting a large, overhanging roof (but see McCullagh & Tipping, 1998, pp. 42, 104–105). In Scotland, such low stone walls often survive in upland settings, and have been referred to as hut circles mainly of Bronze Age date (Halliday, 2021, pp. 90–92). Excavations at sites like Cuil a' Bhaile on the Isle of Jura or the roundhouses at Lairg, Sutherland, suggested the existence of upper turf walls (discussion in Romankiewicz, 2019; compare McCullagh & Tipping, 1998). A similar potential has been identified for a stone-based roundhouse at Inverewe, Sutherland (Rhodes, 2017). Here, full analysis is still underway to understand the massive character of the stone base and the remaining sediments above (Gardner, 2018 for initial geoarchaeological analyses).

A particular unusual stone construction, albeit in character not unlike the massive wall at Inverewe, has recently been investigated at Old Kinord and New Kinord, Aberdeenshire. A series of large roundhouses, between 13 and 16 m in diameter, consisted of large upright slabs and boulders outlining an inner and outer wall face. These retained a rubble core, rendering the overall walls more than 3 m wide (Figure 5b). The hypothesis that these massive stone settings could be the bases for substantial upper turf walls has been confirmed by micromorphology, by sampling two consecutive roundhouse structures at the Old Kinord site (Romankiewicz et al., 2020a). Turf wall collapse has been identified by still articulated blocks, with micromorphology confirming that these blocks had been cut from a slightly wetter soil than the surrounding topsoil. This had given the blocks a distinctively reddish hue (Banerjea, 2017, Banerjea & Morandi, 2018; for further suspected evidence of such massive stone bases for upper turf walls see Romankiewicz, 2019).

This identification of turf walls by proxy of a stone base can be extrapolated to less monumental turf architectures with less substantial stone components. For example, turf walls have always been assumed for the Pitcarmick-type houses of early medieval date. Excavations and sampling of upstanding turf wall remains at Lair, Perthshire have now demonstrated this construction method for this building type (see above and Reid, Milek, O'Brien, Sneddon, & Strachan, 2022). Micromorphological investigation at the Pitcarmick site itself is awaiting further work, although a turf wall seems the most likely explanation for the evidence of silty sediments above a sparse gravel spread bounding the floor layers. A similarly silty "slump" covering parts of the floor corroborates the interpretation of collapsed turf walls (Carver et al., 2013, pp. 162–163; Illus 13). Such very ephemeral gravel spreads on the line of projected turf walls could represent an accidental residue formed by decayed turf blocks with an originally high gravel content. Spreads of larger stones could indicate a decayed composite turf/stone wall (Strachan et al., 2019, pp. 119–120). Thus, even without representing the remains of a drainage layer, such gravel and stone concentration can still be proxy evidence for a former turf wall.

At the site of a Bronze Age roundhouse near the medieval Pitcarmick house, a thicker gravel layer along the circumference of its footprint seems a likely example of an intentional drainage layer underneath a turf wall, although no obvious silty deposits from a turf wall were recorded (Carver et al., 2013, p. 157, Illus 10–12). Even if more than 2,000 years apart, the corresponding evidence at Pitcarmick makes a good case for turf walls built on gravel footings in upland settings, and might even suggest a long-standing turf building tradition, since turf and gravel sources remained extant on site. The upland vegetation today would indicate that building with turf did not necessarily rely on grass vegetation, but that for example heather turf could be exploited as well.

For the roundhouses at Green Knowe, a prehistoric hillslope settlement in Peeblesshire, turf walls could be reconstructed above a thin, annular spread of gravel similar to Pitcarmick or Lair. At one of the Green Knowe houses, this gravel spread sits within two concentric rows of stakeholes, seemingly marking the outer edge of a roundhouse footprint, and therefore delineating the inner and outer faces of a thick wall (Figure 5c; Feachem, 1963, Figure 3). The evidence seems best interpreted as stakes supporting a formwork of wattling, woven between the stakes to retain an earthen fill in-between (Feachem, 1963, p. 83). In this pastoral upland landscape, the likelihood of using turf on a gravel spread footing as the wall core between wattling seems compelling. The wattling would have helped to retain a turf wall, which may have had to make use of poor-quality upland turf. The feasibility of such a construction using turf off-cuts in a loose mix has been demonstrated in a landscape art installation at Errol, Tayside, together with artist Tim Fitzpatrick (Figure 5d and e).

3.3 Proxy Evidence 3: The Material Trap for Ploughed Out Turf Walls

Many prehistoric roundhouses survive with their postring only, comprising postpits cut into the subsoil. All above-ground evidence has been ploughed out or was otherwise truncated. Some roundhouses have an additional feature surviving, a penannular hollow concentric with the postring. A few of these hollowed features are relatively steep-sided (Kendrick, 1996, pp. 46, 61–64; Illus 27; Pollock, 1998), but the majority present as shallow dishes, the so-called ring-ditches (e.g. Hatherley & Murray, 2021, pp. 72, 77). Many ring-ditch roundhouses have no evidence of the construction of their outer wall surviving, but the hollow often presents a continuous and sharp outer edge, also concentric with the roundhouse footprint. It seems likely that this hollow developed against an outer wall, and given the lack of earthfast features, this has sometimes been reconstructed as an earthen bank or turf wall (compare Figure 5a; Cook & Dunbar, 2008, Figure 195; compare Romankiewicz, 2019, p. 138).

The hollow feature has been interpreted as a result of stalling animals in this zone between outer wall and inner postring (Romankiewicz, 2019, p. 139, compare Jobey & Tait, 1966, pp. 14–15; Reynolds, 1982). It seems less likely though that these were created by wear from the movement of animals, because bedding material would have cushioned against such erosion (Hilary Murray, pers. comm.). More plausible would be that the hollow was a result of periodically removing said bedding saturated with dung and urine, to be used as fertiliser (Romankiewicz, 2019, p. 139). This was a well-established practice in later periods, in Scotland and across most of Northwest Europe (known as "Plaggenwirtschaft" [plaggen economy] using "Tiefställe" [sunken-floor byres], Ellenberg, 1990; Romankiewicz, 2011, pp. 66–67, Barrett, 2015, pp. 37–38, 44, 58; Postma, 2015). Each spade cut or raking action would leave a mark within the ring-ditch area, especially on the sandy, well-draining subsoils on which many of these ring-ditch houses were built. For well-excavated roundhouses, such as those at Kintore, Aberdeenshire, the distribution of individual scoops within the ring-ditch area has been carefully recorded, so that a detailed analysis can reconstruct clearing-out sequences (Romankiewicz, 2018a; see Alexander, 2002; Cook & Dunbar, 2008). These likely represent several episodes of clearing, perhaps over several seasons; however, subsequent actions will have removed previous evidence. Feature depth is therefore an indicator for prolonged clearing and repeated use. Careful documentation of stratigraphic relationships and even ephemeral evidence for cuts is key to understanding these processes (Alexander, 2002, Illus 9).

The interpretation of these features as clearing-out events implies that the structures were episodically emptied and seemingly emptied again after their last use. This is important as all too often the surviving deposits within a ring-ditch are simply assumed to represent activities concurrent with the use of the roundhouse (discussion in Hatherley & Murray, 2021, pp. 13, 17). These fills often post-date the initial use of this area as a byre, having been either deliberately added, perhaps for waste disposal from a nearby building in use, or becoming accidentally trapped. Large amounts of charred timbers found in an Iron Age ring-ditch house at Birnie exemplifies that the ring-ditch hollows also act as traps for building materials, on demolition or from a conflagration event (House D, Hunter, 2009, compare Romankiewicz, 2018b). One such upper fill of a ring-ditch, of the Middle Bronze Age roundhouse Structure 3 at Deer's Den, Kintore, did not contain burnt timber but consisted of a thick, homogenous layer of silts. Analysis has now suggested that this indicates the remains of a collapsed turf wall trapped within the ring-ditch hollow. In this way, the turf wall escaped later truncation. Although no samples for thin-section analysis were taken during the excavations in the mid-1990s that could confirm this upper silty fill as collapsed turf blocks, further evidence exists that renders a collapsed turf wall a likely interpretation. This also forms the fourth proxy evidence discussed here to look out for in the field.

3.4 Proxy Evidence 4: Redeposited Material via Collapsed Turf Walls

The building material turf is not only difficult to detect by the archaeologist in the field, it also complicates the accuracy of dating. Where cut from grasslands that have seen previous human activities, turf blocks can incorporate ecofacts and artefacts, which then become incorporated into the new wall. When this wall collapses, the earlier material is redeposited; if selected for dating, this results in the conundrum that upper fills of structures predate their lower stratigraphy. For example at the Deer's Den Structure 3, Neolithic flints and pottery were found within the thick, silty layer sealing the lower infills of the ring-ditch, which dated to the Middle Bronze Age (Alexander, 2002, p. 21). An inversely dated stratigraphy associated with silty sediments can therefore be another proxy evidence for the former presence of a turf wall (compare House 1, Carn Dubh, Rideout, 1996, p. 148 for flint report, p. 175 for radiocarbon dates). Such conclusions have led Loveday to reinterpret the wall fills at Knap of Howar, Papa Westray (Orkney) as a turf core, rather than midden infill as originally proposed (Loveday, 2006; compare Ritchie, 1984). Loveday's conclusion implies an even earlier occupation, predating the Early Neolithic house under investigation; this earlier activity had taken place in the area of turf-cutting for the later house (Romankiewicz, 2019, p. 138, also for further examples).

At Deer's Den, the flints and pottery sherds in the silty upper fill of the Middle Bronze Age roundhouse match the material discovered in pits immediately in front of this structure (Finlayson, 2002, pp. 54, 56–57). The excavator was careful not to make this connection, but the matching evidence from the specialist report, in light of the interpretation of the upper ring-ditch fills as remains of a turf wall, may suggest that the turf was cut from the area over the Neolithic pits. These were situated immediately in front of the entrance to Structure 3 and to its west (Alexander, 2002, Illus 8). Although evidence from early medieval turf houses at Lair may imply that the turf blocks were sourced away from the immediate settlement area, modern practice shows that reducing the distance between the cutting location of the turf blocks and the building site can significantly reduce construction time and efforts (Strachan et al., 2019, p. 119). Similar considerations have been taken into account for Roman turf constructions (Snyder et al., 2023).

A series of proxies have been identified here to aid field archaeologist to detect the presence of turf architecture and to sample material remains for geoarchaeological analysis to confirm the presence of turf walls. Such a conjoined, multi-scalar approach of field and laboratory methods is important, including carefully sequenced excavation in plan, 3D-recording in plan and section, and a variety of geoarchaeological analyses (Huisman & Milek, 2017; Russell et al., in press, pp. 872–887; case study in Romankiewicz et al., 2022). Similarly, new research led by the author is underway to analyse turf blocks more holistically, using a range of state-of-the-art geochemical and microbiological analysis.

4 Turf's Metamorphosing Character

Turf blocks have shown to be archaeological chameleons, blending in with the surrounding soils and melting back into the ground. Their transformable character transfers onto the architecture constructed of them. This starts with the negotiations with each turf block during construction as described above and continues with the use of the turf structure, its changing uses, and eventual abandonment. Gaining a greater understanding of the malleability, flexibility, and hence the flux inherent in the turf blocks, and transferring this new understanding into interpreting turf architecture, can help to recognise the intrinsic processual nature of this living material. In turn, the processual nature of it helps to recognise the resulting living architecture. Analysis of prehistoric architectures built in turf has shown that the architectural "results" from building with turf are not standardised products, but best described as a series of processes.

4.1 Turf Architecture as Process

Modern architecture is usually discussed as a product – a design idea that is planned for a function, then built, and so materialised and manifested in a construction. From the architect's perspective, reshaping is not needed or not possible without compromising design, construction, and material properties. In the context of heritage management, remodelling of original architectural designs is strongly discouraged or even prohibited (see Romankiewicz, 2021, p. 132). Lesley McFadyen has identified such interpretations of architecture as only constituting one point in the process of building (McFadyen, 2006b, p. 93). She compares this with more agile "quick architectures" described as processes within a network comprising various actors. These include stone, mud, turf, and humans as well as intangible agents such as structural loads and inherent dead weights of materials (McFadyen, 2006a,b, p. 94). McFadyen identifies such event-based processes already for Neolithic long barrow constructions (Bailey & McFadyen, 2010; McFadyen, 2006a,b). Thinking also about later turf architecture in this dynamic way reveals its inherently flexible, malleable, and changeable character (Romankiewicz, 2018a).

Identifying the dynamics in turf house architecture starts with the repeated, ad hoc, *in situ* repairs introduced above for the Icelandic building tradition. The replacement of individual turf blocks means houses can rarely be pinpointed to a specific construction date as individual parts have been rebuilt over time.

> The turf farmhouse [in Iceland] can therefore often be understood as a continuous and organic building process from the dawn of settlement. (Stefánsson, 2019b, p. 14)

The replacement of parts of a turf wall or roofing not only casts turf buildings into a constant process of being and becoming, but this also blurs the boundaries between building and rebuilding itself, as materials are also reused (Stefánsson, 2019b, p. 14, compare Romankiewicz, 2021, pp. 136–138). Some parts saw replacement, while still-functional elements were retained or reused because good materials were scarce or the efforts in obtaining these could be spared (Ágústsson, 1998 [1981], p. 56). Only decayed material was replaced but could be composted (Stefánsson, 2019b, p. 17). Today this would be described as sustainable building practice: reduce, reuse, recycle.

Within this process over time, a turf house therefore turns into a palimpsest of materials from different events of building and rebuilding (Figure 2; compare Lucas, 2021, pp. 91–93). In the same way as earlier material contained within a freshly cut turf block complicates absolute dating methods, the replacement of individual blocks with younger ones or the reuse of older blocks complicates the relative phasing of when a building's shape and layout was first constructed (compare Evans, 2013 on complicated "narratives" beyond individual buildings). The genotype of a turf house as it was first conceived may be of very different date to how its phenotype presents in the present (compare Romankiewicz, 2011, pp. 24–25 for similar discussion of drystone architecture). Since building methods did not see substantial changes over time, traditional methods from buildings archaeology also have only limited success in disentangling individual phases (Stefánsson, 2019b, p. 14).

What Stefánsson describes for the Icelandic turf building tradition maps neatly onto the evidence of prehistoric turf architecture in Scotland, where buildings similarly present as ongoing processes, not short-lived, single-use products. Building with turf was an investment in a place, not in a structure. The continuity of building on a single spot vs the changeability of its structure, documented for the Icelandic farmhouse, can also be seen in the Scottish prehistoric tradition, in the continuous use and reuse, rebuilding, and remodelling on the same site.

The Scottish prehistoric evidence moves even further as the discussion of the Deer's Den Structure 3 will show below. With the use of turf as a building material, a concept is established that would today be described as a circular economic system, with an architecture at its core that is derived from the soil and returns to it again when the cycle restarts.

4.2 A New Meaning of Circular Building

Returning to the case of Deer's Den, its Structure 3 exemplifies this prehistoric circular economic model. To explain this cycle, and to trace it in the archaeological evidence, the analysis must start with the end of a structure on this plot, not with its beginning. This is particularly important given the complications to identify a first original turf structure as discussed above.

The final use of Structure 3 as preserved shows a shallow depression over its entire footprint, ca. 12 m in diameter, offering about 450 m^2 of floor area (Figure 6a, in red). The evidence suggests a light wear within a large house with no substantial clearing out activities, perhaps only light brushing consistent with human dwelling rather than for stalling animals. This last surviving footprint on this stance is minimally offset from an earlier structure and was built with a larger postring (c. 9.25 m diameter, compared to c. 7.25 m). Enough of the earlier structure must have remained in the landscape for the later house to return and reoccupy this spot. The new house was built over the homogenous silty infill of the earlier ring-ditch, which represents the earlier, collapsed turf wall as discussed above.

The earlier roundhouse consisted of several phases of use, indicated by the depths of the ring-ditch and the multitude of clearing-out events already discussed (Figure 6b–e). A series of intercutting pits and elongated

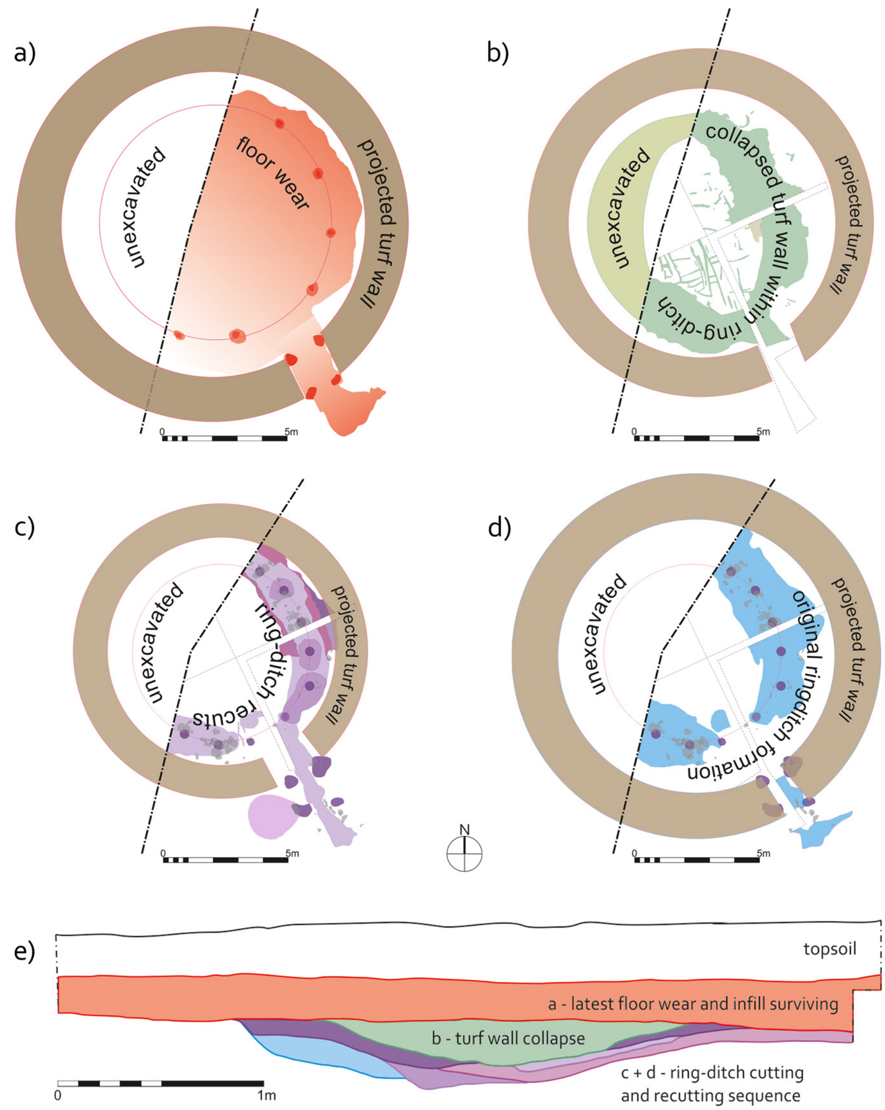

Figure 6: (a–e) Ground plan series of Structure 3, Deer's Den, Aberdeenshire, Northeast Scotland, starting with the final phase surviving (a, in red), collapsed turf wall surviving in ring-ditch hollow underneath (b, in green), preceded by a series of ring-ditch uses (c and d, purple and blue as the earliest). (e) Section showing ring-ditch cutting sequence and infills (Drawings: Tanja Romankiewicz after Alexander, 2002, Illus 8 and Illus 9, as well as a series of field drawings).

hollows seen in section of the ring-ditch area corroborates the evidence of repeated use. Pottery from these first-phase features suggests domestic functions (Alexander, 2002, p. 21). An area of heat-affected sand in the northeast quadrant likely represents the remains of a hearth removed in a later use. Together with the latest phase of shallower wear, the superimposed evidence on this plot suggest that a building started out as a house for human occupation and ended as such. In-between these dwelling functions, the ring-ditch phases imply the use as a byre or byre-house with animals stalled in the penannular space.

The early sequences of ring-ditch use suggest that the clearing-out events eroded away the postholes as well. Some posts may have had enough substance to remain upright; others may have been reset on postpads, since flat stones survive near the projected original position of the postholes (Figure 6c, stones in grey). The first use of the ring-ditch area seems to have been relatively broad, but remained shallow (Figure 6d, in blue). In a second phase, the clearing-out cut deeper, and at a steeper angle, creating a narrower ring-ditch footprint (Figure 6c, in purple). Repairs to the entrance postholes support this interpretation that the footprint of the house was narrowed over time, from an initial 11 m of internal diameter reduced to c.9 m. Hjörleifur Stefánsson notes similar practices for Icelandic farmhouses.

> During a rebuilding the house will often take a somewhat different form depending on the prosperity of the farm or change in natural conditions. (Stefánsson, 2019b, p. 14)

The flexibility of the turf wall allowed remodelling of the outer wall, and as evidence from other Middle Bronze Age roundhouses in the Kintore area shows, this could even lead to a roundhouse footprint becoming more oval and amorphous over time (Romankiewicz, 2018a). The activities inside the structure shaped its inner layout and subsequently its outer shell. As seen in the sequence of clearing-out episodes here at Structure 3 Deer's Den, or at roundhouse 26 at Kintore nearby, these activities seemingly encroached into the projected wall area of a truly circular roundhouse. It seems therefore likely, as Stefánsson records for Iceland, that outer turf walls were remodelled, reduced, or expanded, and metamorphosed under the pressure of activities inside the building to accommodate changing needs. Similar to the Icelandic tradition, this was a gradual process; discussing these metamorphosing processes in a strict archaeological framework that thinks in separate building phases cannot capture the continuous change implicit and facilitated by building and living with turf walls.

In fact, the final footprint of the ring-ditch area at Structure 3 Deer's Den (Figure 6b, in green) suggests that this hollow had encroached not only into the turf wall, but also into the central area, typically interpreted as the living space of a byre-house. In the ring-ditch phase marked here in green, this internal "dwelling" space became reduced to an oval of about 4.2–6.5 m across, totalling an area under 30 m^2. This is only about a tenth of what was available to the inhabitants of the first 8–11 m roundhouse footprints prior to the developing ring-ditch (Figure 6d), who would have had between 200–300 m^2 at their disposal, and even less compared with the 450 m^2 offered inside the latest house (in red, Figure 6a). In light of these dimensions, it seems unlikely that humans and animals shared the same space when the ring-ditch was at its fullest extent, especially if allowing for some truncation of upper fills. The central area most likely served only as access to distribute water and fodder and provide day-to-day animal care. The cattle farmers who kept their animals in this structure must have lived elsewhere on site. In fact, the fills of the latest ring-ditch, before the collapse of the turf wall on top of these, contain discrete lenses of hearth waste and other domestic refuse (Alexander, 2002, p. 21). After the farmers took out their animals for one last time, they may have filled the ring-ditch with the waste from the building they occupied nearby. The well-recorded tipping lines within these final deposits indicate not only dumping from within but also from the outside edge, which suggests that even parts of the wall had been removed by this stage.

Perhaps this was a gradual change from dwelling to byre, from a shared space to then animals taking over; or it was an abrupt switch with no intermediate byre-house phase. This use also came to an end after a sequence of stalling animals, perhaps overwintering vulnerable ones indoors, then removing them and their manure in spring, to fertilise the fields. The end of the byre use did, however, not constitute the end of activities on this spot as ephemeral archaeological evidence demonstrates. The turf walls may have deteriorated or were pushed over, but ancient ploughmarks, so-called ard marks, survive across the thick deposit representing the collapsed turf wall to indicate continuous human use. The spot that had been enriched with nutrients accumulating over the years, from ashes and burnt bones, manure, and fodder, was now used to cultivate crops. The turf wall, which "stored" humic topsoil in each of its blocks, had similarly soaked up nutritious residues from previous uses. With its collapse, in all likelihood deliberate to create this garden plot, the turf wall added to the layers upon layers of embeddedness of human activities in this spot. The turf wall added topsoil and composting plant remains at a macroscale, and trace elements of nutrients at microscale.

The structure that was turned into a garden was not old and exhausted from the various changing uses, but enriched in nutrients, soil bacteria, and fungi, to now allow for intensive crop cultivation on a concentrated plot. The enriched matter was not thinned out on fields anymore, it was used on the spot, likely to grow high calorific crops (compare Guttmann, Dockrill, & Simpson, 2005; Guttmann-Bond, 2019, pp. 95–103). Ethnographic evidence in Shetland for example shows that such garden plots were often enclosed again by turf walls, to keep out livestock and protect the crops. Pollock assumed similar practices to explain his Iron Age evidence at Ironshill, where he reconstructed parts of the outer roundhouse wall to remain standing after abandonment. It retained the cultivation soil accumulated in the interior. This soil mix shows similar signs of ploughing or hoeing as at Deer's Den, and may well represent a collapsed turf wall (Pollock, 1998, pp. 348–350, Illus 13). In these cases, the fertiliser was first brought to the fields, but in a later step, the fields were brought to the fertiliser (Romankiewicz, 2019, p. 139). Only after the Deer's Den garden plot became gradually depleted of its riches did the dwelling use return. This took the form of the latest surviving footprint of 450 m^2. This latest structure could have seen similar ongoing uses as the ones before, at stratigraphically higher levels. However, such uses were then truncated by later ploughing and do not survive. This means the latest remains recognisable by archaeologists, here dated to the Late Bronze Age following a continuous presence on this plot for 300–500 years, does not necessarily equate with the end of the sequence. It only represents the end of the archaeologically recognisable uses on this plot, which remained undisturbed and un-homogenised by later ploughing (compare Evans, 2013). What is important of this presence, in its various forms of occupation and activities is that its continuity on this spot is not narrowly defined by human habitation. Domesticated animals and cultivated plants have also inhabited this spot, and were tended by people; continuous human presence can therefore vary greatly in its intensity, but it means this site has not been abandoned entirely.

4.3 The Circle of Use and Reuse in a Wider Prehistoric Landscape

The analysis of Structure 3 Deer's Den has shown that the continuous use of a plot does not necessarily equate to fully walled and roofed houses; other forms of use and reuse involving architectural structure and building materials can be reconstructed from the evidence, with a variety of actors. Whether upstanding or collapsed into a layer that can be ploughed, it is the presence of turf architecture in all its forms that most closely indicates these continuous uses. Through turf's metamorphosing character, the boundaries between individual uses become blurred. Trying to separate out traditional archaeological phases becomes difficult, and in fact insignificant. The use of the byre area may have been a gradual introduction, a gradual take-over of this house. Evidence at other houses may be different, according to different needs and circumstances. What is important is to recognise the continuity in presence on a site, which is in place and matter, and not in built structure. At Old Kinord for example, with its sequence on the plots of Circle A and D, houses turn into yards and become houses again, some with and some without later byre use. Yet for the dwelling use shifting across plots A and D, it seems to have been important that it retained a physical connection to the older structure. The deliberate, and structurally challenging overlap between the walls of Circle A and D, and likely the incorporation of an even earlier house, confirm this need of physical contact and continuity (Romankiewicz et al., 2020a). This connection between earlier and later structures, sometimes tangential as at Old Kinord, sometimes as accurate as possible as at Deer's Den, shows the importance of tying matter into one place, tying activities to this place, safeguarding investments into one place. This place-making also explains why remains of turf walls were retained, either as low banks as at Ironshill or with their stone or gravel footings intact as at Pitcarmick or Green Knowe. The upstanding banks in particular retain the nutrient-rich soil, protect the garden plot, and maintain the reference of the former house structure. Places of habitation remained marked in the landscape and acted as places of reference, as places of continuity to reuse and reconnect.

A wider analysis of such patterns across prehistoric uses of turf architecture suggests a shared underlying concept of such investments into place through architectural matter, but this lies beyond the scope of the present study. What is clear already from these few case studies presented here is the reliance of this circular economic model on the building material turf. While the wider analysis under preparation also considers Bronze and Iron Age rectilinear houses of the North Sea regions, it is rather fitting that the examples introduced here to explain the circularity in this concept materialises this through roundhouse building. The wider study though demonstrates that circular concepts do not need to find expression in circular architecture. Similar notions of circularity can develop from a deep understanding of the material beyond architectural shapes. As the citations referring to the Icelandic turf building tradition show, similar practices also appeared in medieval and post-medieval Iceland, there associated with rectangular architecture. Given that comparable practices developed from using the same material confirms the close link of such circular concepts with the properties of turf – beyond architectural form and functions and across time.

What ties these shifting turf shells into place is their embeddedness into the circular economies of their material. With sods cut on or near the site as suggested by the evidence from Deer's Den, the buildings made from these blocks attain an embeddedness into their landscape that is so intimate and ultimate that it can rarely be achieved by other materials. This is emphasised by the fact that the turf walls depending on their condition and structural details can also regrow on the outside, which blends these walls into the surrounding pastures (Figure 1; Ágústsson, 1998[1981], p. 54). The possibility of then composting the turf walls after they have become an enriched resource of humic soil on which more crops can grow completes this circular economy. In this way, building with turf becomes sustaining. It sustains the household building with it, but via many different physical forms: as a house for dwelling, as a byre for housing cattle or sheep, and as a garden for "housing" delicate crop. The cycle continues, not just restarting at several points within these stages, but as a continuum without a strict beginning or end. It restarts when a pasture that had become too compacted by sheep hoofs and needed aeration was deturfed to yield turf blocks with a dense sward and root matting that is so beneficial for turf wall construction. It restarts when the old growing location regrows to produce the new turf for a new structure, when the turf walls are composted to produce new crops. The cycle also extends beyond a final dwelling use, when for example a turf-walled house is turned into a burial mound, perhaps for one of its inhabitants, as evidence from Scandinavia suggests (Eriksen, 2016).

It seems therefore not just a matter of scale and dimension that prehistoric structures survive so poorly compared to Roman turf structures. If this transformation through reuse of prehistoric turf buildings is inherent to their material and materiality, then these cannot survive to any substantial extent. Their ephemeral evidence is their intrinsic character.

Within this circular practice reliant on the matter of turf, grass, roots, and sediments, human lives and human minds are woven into a place, via materials and matter. In fact, all the different occupants become interwoven through the reuse and recycling of turf. Banfield recently identified such "architectural entanglements" from interweaving earthen materials, plants, and animal bones via human construction processes at the Salisbury Plain and Avebury earthen long barrows. Although dating to the Neolithic period, these represent similar processes, which Banfield identified as "acts of propagation" beyond construction, including erosion, degradation, and reclamation (Banfield, 2018, pp. 197–198). Here as there, circular practices embed turf architecture into wider cyclical processes beyond a built structure and into the landscape. Turf architecture and its material are the carrier within this cycle. In this way, turf architecture is not only sustaining, but also sustainable.

For archaeologists, architecture has always been one indicator for human presence in a landscape, but turf architecture demonstrates that built structure is not necessarily the defining one. What defines and contains the evidence for human presence on the spots discussed here are the turf blocks, and their soil memories, of activities that happened before a structure was built, of what happened when this structure was used, and what happened after this structure was abandoned. The dynamics in this circular economy depend on the mobility of the turf blocks, from pasture to wall, to garden soil, and to becoming a turf block again for a new wall. It is this mobility of the turf block, its flexibility and malleability, that renders turf architecture as a process that becomes difficult to grasp with existing archaeological terminologies and existing methodologies of study. The examples here have shown that geoarchaeological methods, such as micromorphology, are best suited to understand the complexities of turf architecture and turf archives. The case studies have, however, also suggested that in order to write archaeological narratives of turf architecture, its inherent cyclical concepts of growth, use, composting, and regrowth will need to be similarly applied, to enable archaeologists to interpret turf's ephemeral archaeological remains comprehensively and holistically.

5 Circular Arguments: Today and for the Future

The study has taken a path from confirming physical evidence of turf architecture to identifying theoretical concepts behind the building with turf. It has argued for a greater presence and importance of turf building in prehistoric records than previously anticipated. The examples cited have shown avenues for detecting evidence for turf buildings, even if ephemeral, or for proxy indicators recognisable in the field. Discussion has signposted towards geoarchaeology and micromorphology in particular as methods to confirm and describe turf architecture. This requires a multi-scalar combination of field and laboratory analyses to expand our documentation and understanding of the use of turf in prehistory. The roundhouse case studies have mapped the circular nature of building with turf, and the way turf fuelled circular economies that tied pastures, house- and byre-construction, and intensive crop-cultivation into wider landscape management schemes. It has arrived at a prehistoric concept of architecture that incorporates the flexibility, malleability, and mobility of turf to its advantage. Results suggest that in order to study this circular use, and in order to learn from it, we need to move away from an understanding of architecture as product, and consider it instead as process. Turf architecture may only superficially appear as ephemeral and impermanent; its permanency is not in its original structure, but in its shifting shells and the matter left behind. Turf architecture sustained households in different ways; sometimes as roofed buildings, sometimes as unroofed walled gardens. Such new thinking also offers new perspectives on the very substance of architecture, not exhausted and abandoned after a time of use, but transformed into a nutrient-rich resource: a concept of architectural metamorphosis (Romankiewicz, 2018a). The ubiquitous use of turf architecture across the northern hemisphere renders such a rethink more widely applicable than to the Scottish case studies discussed here.

Learning these ways of thinking from the past, and not only just as found in the residues in the ground but also in the concepts in people's minds, can help moving forward towards more sustaining and sustainable practices today (Guttmann-Bond, 2019, pp. 128–130). This new concept of a circular turf economy proposes a holistic, long-term, multi-scalar perspective compared to more functionalistic, linear "cradle-to-grave" interpretations of buildings. This contrasts with the traditional equation of "house lives" with birth (build) and death (abandonment) (see e.g. Brück, 1999; Gerritsen, 2003). This new research here argues for a cradle-to-cradle approach to understand Being, Becoming, and Belonging in the built environment (compare Romankiewicz, 2021), perhaps better referred to as the "curated" environment to reflect the ongoing processes within an architecture borrowed from the soil to which it can return.

This new approach also translates into modern ecological economics concerned with natural and social capital accountancy, because it can identify tangible values of space, place, and belonging. In a recent experiment, working with turf builder and archaeologist Daniel Postma, as well as with colleagues from Historic Environment Scotland and an interdisciplinary community of researchers and volunteers, we have started testing this circular concept in a modern context. Together, we have built two structures, an enclosure offering a turf bench and a turf-walled hut (Figure 7). These are not experiments to replicate the past, but to translate

Figure 7: The modern turf structures built at Comrie Croft, Perthshire, central Scotland; left: roundhouse structure with modern windows and stove; right: turf bench. Photographs: Tanja Romankiewicz.

ancient concepts into modern contexts. The practicing of the ancient practices has opened a new dimension of understanding the sustainability of building with turf, not in the past, but for the future. By calculating the carbon output and input of turf architecture within the circular turf building economy and adding its benefits from natural, social, and cultural values of building with turf, we aim to demonstrate the relevance of turf architecture to discussions on natural, sustainable modern building, towards net-zero architecture.

Maybe those participants, having learned about turf's circular concepts from the past and looking at this material differently now, will multiply and become multipliers. How about turf walls instead of metal fences? Or turf buildings for storage with living, breathing walls? As compostable byres, as recreational, compostable huts? As buildings that tread lightly on the soil, that are only borrowed from the soil, and that can easily return to it, without increasing our carbon footprint.

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