



# The use of predictive modelling to target Neolithic settlement and occupation activity in mainland Scotland

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## ABSTRACT

A central aim of Neolithic studies in Europe is to understand settlement or domestic activity of the first agriculturalists. In Scotland, the continued absence of unambiguous Neolithic settlement or domestic occupation activities on the mainland remains an unresolved issue. It is proposed that areas attractive for settlement and occupation activities may be identified by constructing GIS-based models of sites believed to be related to settlement or occupation activities, including chambered cairns, timber halls, and sites containing pit-digging episodes. Statistical analyses undertaken in this process suggest new insights into the locations of the chambered cairns, timber halls, and pits. Finalised models are constructed and desktop assessments are conducted to examine model performance. Research priorities for improving significant environmental variables driving the current models are identified.

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## 1. Introduction

The only indisputable Scottish Neolithic settlements are multi-phase, primarily stone-built structures found in the Northern Isles on Orkney and Shetland (Calder, 1956; Childe, 1931; Childe and Grant, 1939; Clarke, 1976; Clarke and Sharples, 1990; Fraser, 1983; Ritchie, 1983, 2000; Whittle, 1979, 1986). The absence of similar sites on the Scottish mainland is difficult to explain (Barclay, 2004; Brophy, 2006; Darvill and Thomas, 1996; Kinnes, 1985), despite recent fieldwork targeting settlement and occupation activity in the northeast (Barclay, 2003a, 2004; Barclay et al., 2003). It may be the result of poor preservation of timber, which is likely to have been the dominant building material, or a combination of historical and geographical biases in discovery patterns (Gibson, 2003). Alternatively, if mainlanders at this time formed mobile groups or communities, temporary or seasonal shelters may instead have been used (Barrett, 1994; Pollard, 1999; Pryor, 1988; Thomas, 1991, 1999; Whittle, 1996, 1997). These arguments are difficult to resolve

due to the lack of clear evidence for Neolithic settlement or occupation activities on the Scottish mainland.

In light of this problem, this paper presents new geographical information system (GIS) based models that suggest where Neolithic settlements or occupation activities may be found. The models are constructed using environmental patterns derived from the locations of other *input sites* on the Scottish mainland, including megalithic tombs known as chambered cairns, timber halls, and sites exhibiting phases of pit-digging. These sites exhibit activities believed to be related to nearby occupation or settlement activities. By estimating where these sites may be found on the Scottish mainland, a built-in assumption is made that the models will simultaneously identify areas that may have been attractive for settlement or occupation activities.

To do this, established techniques are used to create archaeological site prediction models. A GIS is used to extract environmental data at the locations of input sites. Statistical analyses of these data reveal new information about patterns at site locations. The data is processed into logistical regressions, which are applied in the GIS to produce two finalised geographical models.

The first step of model construction requires quantification of environmental trends across the input sites over the whole of the

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mainland. The proposed method determines this efficiently, and is advantageous because such information would otherwise be difficult to discern. The trends are subjected to significance tests, providing clear insight into how the environment may have influenced where Neolithic people chose to locate sites. Limitations are made explicit and performance is estimated with desk-based techniques. Finally, suggestions are made about how these models may be improved and utilized.

## 2. Justification for model input sites

The clearest evidence for Neolithic agricultural activities on the Scottish mainland comes from seven structures excavated at six timber hall sites. The earlier sites (c 4000–3600 cal BC) include Balbridie (Fairweather and Ralston, 1993), Claish (Barclay et al., 2002a) and Warren Field (Murray et al., submitted for publication). The later examples appear from between c. 3500 and 3000 cal BC (see Brophy, 2007, 86–87) and include the two Balfarg Riding School structures (Barclay and Russell-White, 1993), Littleour (Barclay and Maxwell, 1998) and Carsie Mains (Brophy and Barclay, 2004). The plans of the timber halls appear similar (Barclay et al., 2002a), but while the earlier structures may have supported roofs, the later incarnations most likely could not. Both types were probably used as the locations of communal activities, which sometimes included deposition of large quantities of cleaned cereal grains within post-holes (Fairweather and Ralston, 1993). As midden material and domestic artefacts are absent, it is increasingly unlikely ‘timber halls’ were households, though organic materials would rarely survive in the acidic soils (Barclay, 1996; Bradley, 2007; Brophy, 2006, 2007; Fairweather and Ralston, 1993; Noble, 2006; Sheridan, 2007; Thomas, 1996; Tipping et al., 2009). It is possible the grain could have been brought on-site by people living close by (Tipping et al., 2009). The models should include the timber halls because they produced the earliest direct evidence of mainland Scottish agricultural material, and their communal functions indicate they were significant locations in areas attractive for settlement or occupation activities.

The model includes sites with pits that contain deposits of material as evidence of settlement or occupation activity that took place on site or nearby. The pits often contain pottery sherds, less often worked stone, and occasionally charred organic remains such as grains and hazelnut shells (see Appendix 1). The cut-and-backfill single episodes indicate the pits were probably not food storage containers (contra Field et al., 1964). The Scottish mainland pits do not appear unique; recent regional overviews suggest Neolithic pit-digging activity across Britain and Ireland produce similar pits and deposits, though the reasons behind such behaviour remain unclear (Garrow, 2007; Garrow et al., 2005; Lamdin-Whymark and Thomas, in preparation). Some mainland Scottish pits occur near hearths and post-holes that suggest temporary or short-term timber structures, possibly for shelter. Better-preserved examples include the possible wooden structure and associated hearth pre-dating the early Bronze Age Clava ring cairn at Raigmore (Simpson, 1996), the pits and post-holes at Kinbeachie (Barclay et al., 2001) and the pits, hearths and post-holes at the highly disturbed site of Milton of Leys (Conolly, 2001; Conolly and MacSween, 2003). The pits may have accumulated during ritualized disposal of secondary refuse material, where broken or expendable objects and debris are collected and moved away from their initial domestic context into a new location, by a process that LaMotta and Schiffer (1999) (pp. 21) define as secondary deposition (see also Rathje and Murphy, 2001). On the other hand, when the pit-digging and deposition activity precede activities requiring considerably more time and resources, such as the building of an important monument (see

Appendix 1), a different process may be responsible. These pits could represent a kind of ‘softening of the ground’ technique used in the process of claiming ownership of an area or territory, at locations that were important to communities occupying territories or living in settlements nearby (Barclay and Russell-White, 1993, 167–168). For these reasons, it is important to include these sites in models that focus on where settlement or occupation activity took place.

The locations of megalithic stone tombs, known as chambered cairns, have long influenced ideas about where settlements or occupation might have occurred. This is partly because the cairns were built and remained in use during the Neolithic throughout the Scottish mainland (Davidson and Henshall, 1991; Henshall, 1963, 1972; Henshall and Ritchie, 1995, 2001). Such is their importance, Renfrew (1973, 1976, 1984) argued they represent a kind of land tenure and symbolize territorial control for populations under stress (see also Chapman, 1981, 1995; Fleming, 1973). The Neolithic people who built these structures may have ensured the locations of their monuments were close to where they were living (Davidson and Henshall, 1991; Henshall, 1963, 1972; Henshall and Ritchie, 1995, 2001). Recent research on the Orkney–Cromarty cairns around the Moray Firth suggests monuments overlook areas containing high volumes of worked stone, which Phillips and Watson (2000) and Phillips (2002) believe indicate nearby settlements. The possible occupation at the pit-defined site of Kinbeachie is compatible with this argument, which has been extended to the northern distributions of Orkney–Cromarty cairns, though significantly not for the Orcadian examples (Phillips, 2003; Woodman, 2000b). The model methodology extends these ideas by building a database of environmental characteristics from the location of the mainland cairns. If the cairns produce significant environmental patterns then their locations were probably not random, and it is a reasonable inference that these were important locations around which settlement or occupation activities may have been situated.

In summary, locations of settlement or occupation activity on the mainland are believed to be related to the locations of the timber halls, pits, and chambered cairns. How close the settlement or occupation activities are to these sites is unknown, but believed to be nearby. The built-in presumption is that modelling the locations of the input sites also identifies nearby areas that may have been attractive for settlement and occupation activities. However, until demonstrable settlements or occupation sites of this period are found near input sites, it is unknown whether the inbuilt presumption of the model is true. It is hoped that testing these models via fieldwork in the future will lead to a resolution.

Quantifiable data are needed to create statistical statements about patterns in the locations of archaeological sites (Kohler, 1988). Drawing on established techniques for predicting archaeological sites using quantifiable data, a GIS is used to extract environmental variables commonly used in archaeological predictive modelling from input sites and non-site locations; the variables include elevation, slope, aspect, local relief, distance to the nearest source of water, cost–distance to the nearest source of water, and viewshed (Judge and Sebastian, 1988; Kamermans et al., 2009; Kohler, 1988; Kvamme, 1990, 2006; Legg and Taylor, 2006; Maschner and Stein, 1995; Mehrer and Wescott, 2006; Parker, 1985; Rua, 2009; van Leusen et al., 2005; van Leusen and Kamermans, 2005; Verhagen, 2007; Westcott and Brandon, 2000; Woodman, 2000a; Woodman and Woodward, 2002) (Table 1).

Use of environmental data has been strongly criticised as producing conclusions that restate “obvious relationships” (Gaffney et al., 1995, 211) about the locations of archaeological sites. By

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