MEDIEVAL LANDSCAPE TRANSFORMATION IN THE SOUTHEAST AND EASTERN BALTIC: PALAEOENVIRONMENTAL PERSPECTIVES ON THE COLONISATION OF FRONTIER LANDSCAPES

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Abstract

The history of the medieval Baltic is dominated by the crusading movement of the 13th to 15th centuries. The crusades resulted in significant changes to the organisation, ownership and administration of the landscape, with a significant shift in patterns of land use. However, our understanding of the environmental impact of the crusades has been almost exclusively informed by written sources. This paper synthesises existing palynological evidence for medieval landscape transformation in the southeast and eastern Baltic, focusing on the ecological impact of the crusading movement, and considers some key questions, challenges and priorities for future research.

Key words: Crusades, human impact, woodland clearance, agricultural intensification, palynology.

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Introduction

Palynological studies in the southeast and eastern Baltic have contributed significantly to our understanding of the vegetation history of Europe during the 11,500 years since the end of the last (Weichselian) Ice Age (e.g. Saarse, Veski 2001; Poska, Saarse 2002; Ralska-Jasiewiczowa *et al.* 2004a; Niinemets, Saarse 2007; Stančikaitė *et al.* 2004). In addition to preserving valuable records of past vegetation and environmental change, pollen from Baltic peat bogs and lakes also retain important evidence on human impact histories, often in the form of evidence for woodland clearance and agricultural activity, reflecting successive periods of settlement expansion and abandonment. The majority of palynological investigations, however, have tended to focus on reconstructing patterns of vegetation change and land use by prehistoric agrarian and pre-agrarian hunter-gatherer communities, with much less attention paid to landscape transformation during the medieval and post-medieval periods.

What characterises the upper portion of many pollen profiles across the southeast and eastern Baltic is the evidence for vegetation change and land use of a scale not previously encountered. Earlier phases of woodland clearance and agricultural activity are typically smaller in scale and often more limited in duration, followed by woodland regeneration. Vegetation and land use changes from the medieval period are characterised by a significant and often prolonged decline in woodland, particularly in Prussia (present-day northeast Poland), accompanied by an intensification of agricultural activity, marked by a continuous cereal-pollen curve. However, this key horizon in pollen profiles is often poorly dated and studied at a low temporal resolution, presenting difficulties in connecting the palynological data with the wider archaeological and documentary evidence for land use change.

The medieval period, beginning in the tenth century in northern Poland with the formation of the Polish state (Piast dynasty), the 13th century in Latvia and Estonia, and the late 14th century in Lithuania, is a time of significant social, economic and political development, with consequent changes in vegetation and land use. Here, the medieval period can be characterised by the introduction of Christian beliefs and institutions comparable to the rest of Europe. The Teutonic State is unique in being a theocracy established through conquest and run exclusively by military orders and bishops. Christianisation was accompanied by colonisation, particularly in Prussia by German and Polish settlers, marked by the development of networks of towns and settlements, all secured with heavily fortified castles. Conquest, colonisation and religious conversion occurred in tandem with economic expansion and the growth of pan-European trading networks; most notably the development of the Hanse from the 13th century, and the growing trade in Baltic timber and grain (Hybel 2002; Haneca *et al.* 2005; Ważny 2005). These interlinked processes had a significant impact on the medieval landscapes of the southeast and eastern Baltic that are detectable today in the pollen record.

Previous studies of the environmental impact of crusading have been almost exclusively informed by written sources. These sources, often in the form of inventories, demonstrate the diversity and intensity of resource exploitation (Joachim 1973), but date predominantly from the end of the 14th century and lack the longer-term perspective available from the palynological record. This paper aims to demonstrate the contribution that palaeoecological analytic techniques can make to the study of the ecological impact of crusading by providing a synthesis of the available palynological data for medieval landscape transformation from the southeast and eastern Baltic region. By taking a longer-term perspective, it is possible to examine changing patterns of land use over several centuries, and assess the extent to which local environments in the Baltic were transformed from the 13th century as a result of the crusading movement. How is the evidence for landscape change in the medieval period distinct from earlier phases of human disturbance in the preceding Iron Age? Are differences apparent in the nature and timing of landscape transformation, within and between Prussia (Poland) and Livonia (Latvia and Estonia), and between frontier and heartland areas? What are the key questions and priorities for future research?

Study area

The archaeological and historical background

The Baltic crusades involved the conquest, colonisation and Christianisation of present-day northeast Poland, Latvia and Estonia by the Teutonic and Livonian Order (Fig. 1), beginning with the conquest of the Livs (1198–1209) and Estonians (1208–1227) by the Livonian Brothers of the Sword. The island of Saaremaa remained unconquered until 1261. Following their defeat by the Samogitians in 1236, the Livonian Brothers of the Sword were merged into the Teutonic Order, known thereafter as the Livonian Order. Northern Estonia was subsequently ceded back to the Danish crown, but was later reoccupied by the Teutonic Order in 1343. The conquest of Prussian tribal lands by the Teutonic Order occurred from 1235 to 1287, followed by the annexation of Gdańsk and Pomeralia in 1309, and the purchase of the New March in 1402 from King Sigismund of Luxemburg. The Teutonic Order also held additional land within the Polish Kingdom, but only for relatively short periods of time, including the territories of Słupska (1329–1341), Kujawy (1332–1343), Dobrzyńska (1329–1343, 1352–1355, 1392–1405, 1409–1410), Zawkrzeńska (1384–1399, 1408–1411), Wiska (1382–1402) and Żmudź (1398–1409) (Biskup *et al.* 2009, Map 6). It was not until their defeat at Grünwald (Tannenberg) in 1410 that the Teutonic Order's influence began to wane, with their territories progressively disintegrating over the following century, ending in the secularisation of Prussia in 1525. The Livonian Order persisted until 1561, following their defeat by the Russians during the Livonian Wars (1558–1583). Today, many of the Order's castles have disappeared or lie ruined and abandoned, but during the 13th to 15th centuries they were centres for reorganising indigenous tribal territories, and along with towns and colonising settlements, formed the backbone of the new Christian states.

Geographical background

The east and southeast Baltic form the northwest part of the European plain, located within the boreo-nemoral forest zone. The physical landscape is characterised by a uniformly low relief, formed in part as a consequence of successive glaciations; the vast majority of the terrain lies below 100 metres a.s.l., with the highest points in Estonia and Latvia little more than 300 metres a.s.l. There is, however, significant variation in landforms, from upland plateaus to lowlands, marked by numerous lakes and mires, constituting a sizeable proportion (around 10%) of the study area. Woodland remains an important feature of the landscape, accounting for 44% (Estonia), 42% (Latvia), 33% (Lithuania) and 28% (Poland) of the present-day land area. Pine and spruce form the primary component of these woodlands, although much of this is semi-natural or planted; the remaining land comprising a mixture of arable fields and meadows. The study area lies at the transition between continental and oceanic climates, with mean average January and July temperatures varying between -7°C and 17°C in Estonia, and -5°C to 18.5°C in northeast Poland. During winter, the expansion of Siberian high pressure systems can lead to temperatures falling as low as -30°C, with significant southern expansion of sea ice across the eastern Baltic. Mean annual precipitation is between 500 and 700 milimetres per year.

Methods

Pollen studies have been included in this review only if they have accompanying radiocarbon dates ≤ 1500 14C years BP (dating from approximately the fifth to the seventh centuries), providing a broader chronological context for landscape transformations apparent during the medieval period. In total, 72 sequences meet the criterion (Appendix). Many other sequences were excluded from this review, either because they lack deposits of the relevant age, or contain medieval deposits

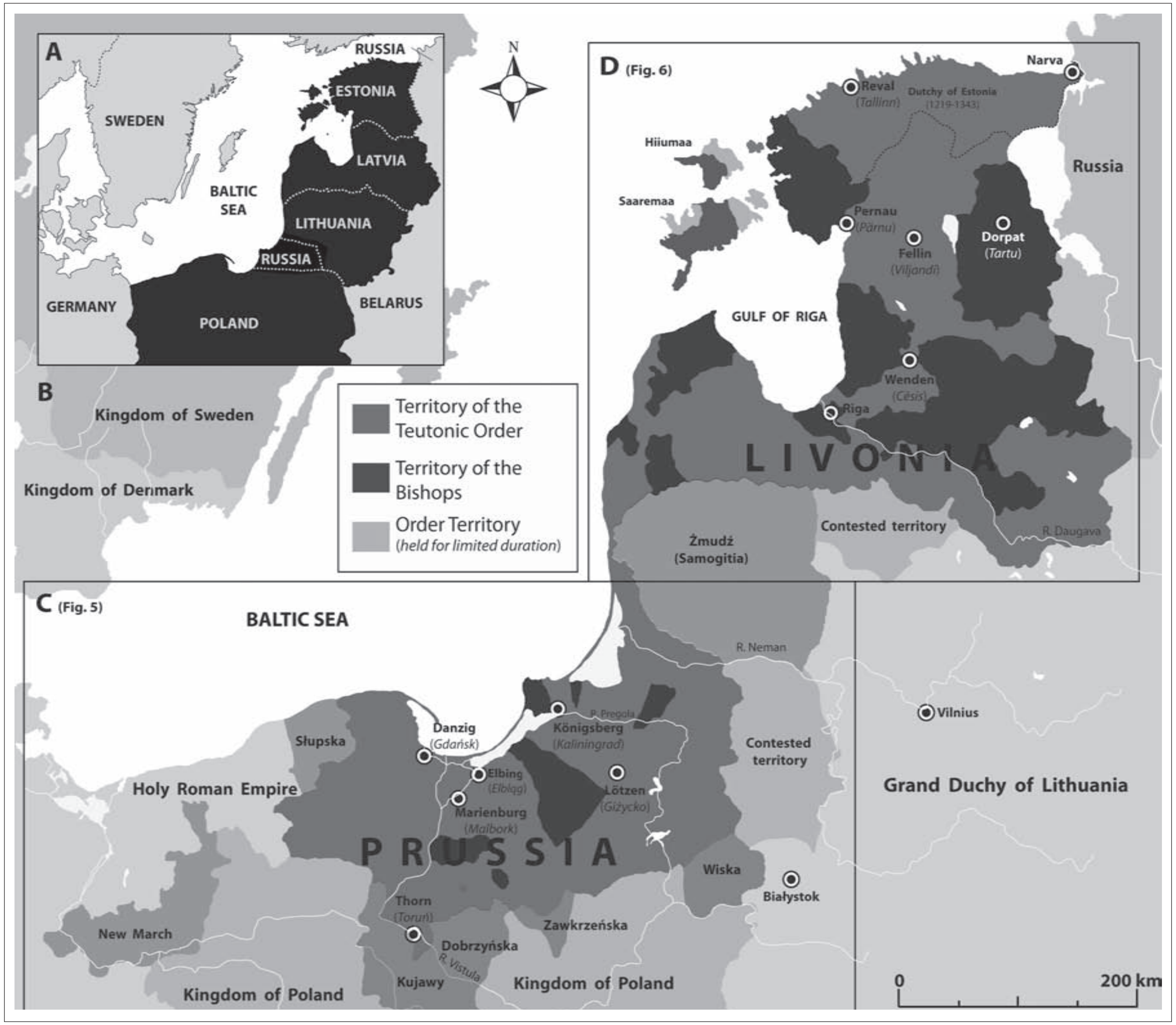

Fig. 1. Map showing: a) part of the Baltic in detail; b) the territories of the Teutonic and Livonian Order, the bishops and the lands of the Holy Roman Empire, the Kingdom of Poland, the Grand Duchy of Lithuania, and Russia; c) and d) Prussia and Livonia (see Figs. 5, 6) (prepared by authors).

that were not directly radiocarbon dated. This by no means represents a complete inventory of pollen cores from the study area, but every effort has been made to include the most relevant sequences. All radiocarbon dates are quoted in uncalibrated years BP, followed by the laboratory code (where provided) and calibrated years AD at 95.4% confidence. Radiocarbon dates with uncertainties >150 years are also excluded.

The palynological resource, its potential and limitations

The palynological studies discussed here cover those lands conquered by the military orders as well as 'contested land' bordering the Grand Duchy of Lithuania along the eastern borders of Prussia and southern Livonia (Fig. 1). Of the 72 pollen sequences (Appendix A), 42 are located within Livonia (Estonia 30, Latvia 11, Lithuania one), 28 within Prussia (Poland 26, Russia one, Lithuania one), and two within contested land (Lithuania).

There is significant variation in the quality of the pollen data, which requires consideration when synthesising multiple sequences across a large geographical area; it is not the intention here to review the pre-depositional formation processes of the pollen record, which are already covered in detail elsewhere (see Moore *et al*. 1991 for a comprehensive review), except, for example, where these may affect the choice of sampling location. Chronological resolution varies enormously between sequences dependent on the sampling interval and number of radiocarbon dates. Long pollen sequences covering several thousand years often lack the sample and chronological resolution required to resolve rapid or short-term changes in vegetation occurring at the sub-centennial to decadal scale. Of the 72 pollen studies, comprising 158 14C dates, half (35 sequences) have only one 14C date ≤ 1500 14Cyrs BP (Fig. 2). This significantly limits the chronological resolution of pollen sequences, irrespective of the sample interval. Issues of chronological precision are particularly important for the medieval period where the resolution offered by documentary sources and key artefact typologies is significantly more precise than the palaeoenvironmental record. Single 14C dates when calibrated may cover a century or more, dependent on the uncertainty and relationship to plateaus on the calibration curve, and can create difficulties in distinguishing between events that may be of either Late Iron Age or medieval date. Multiple 14C dates are therefore necessary to develop more accurate depositional models that enable more precise correlation between the chronological, vegetational and archaeological data.

However, the distribution and coverage of 14C dates is also variable. A significant number of sequences include 14C dates predating the medieval period, particularly those sequences with only single 14C dates ≤ 1500 14Cyrs BP (Fig. 3). Subsequent patterns of vegetation change, therefore, lack a precise chronological context. Sequences with multiple 14C dates at least provide the opportunity to develop depositional models, and here there is more balanced radiocarbon cover-

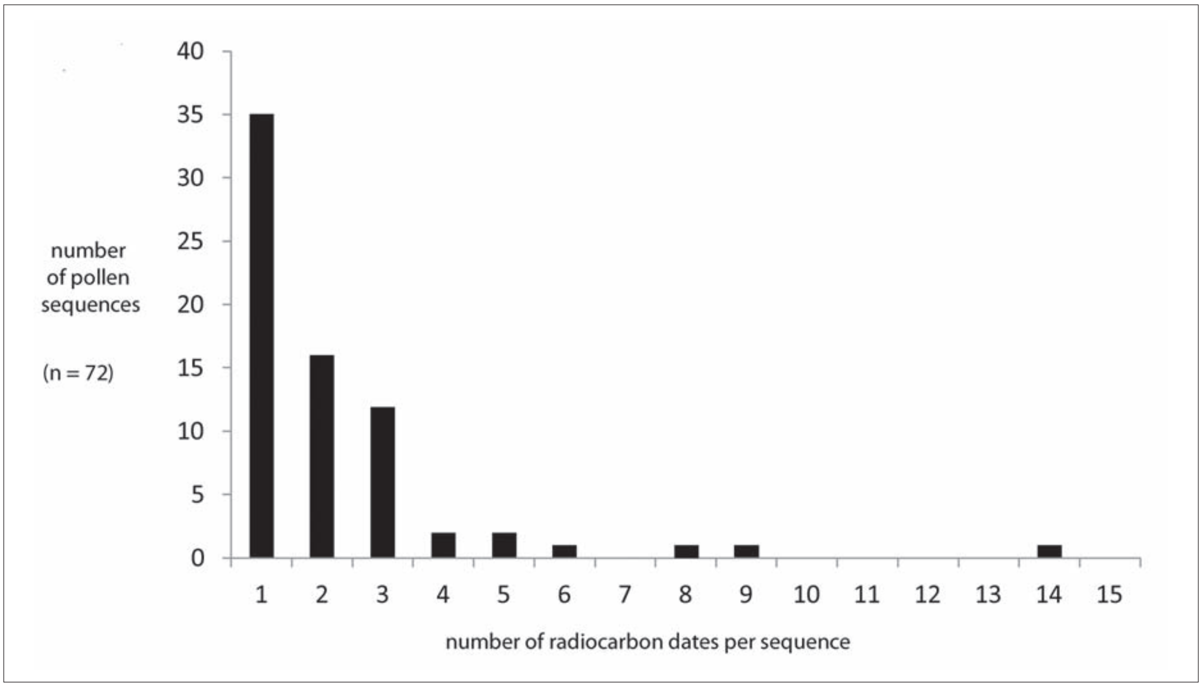

Fig. 2. The total number of radiocarbon dates (≤ 1500 14C years BP) per pollen sequence (prepared by authors).

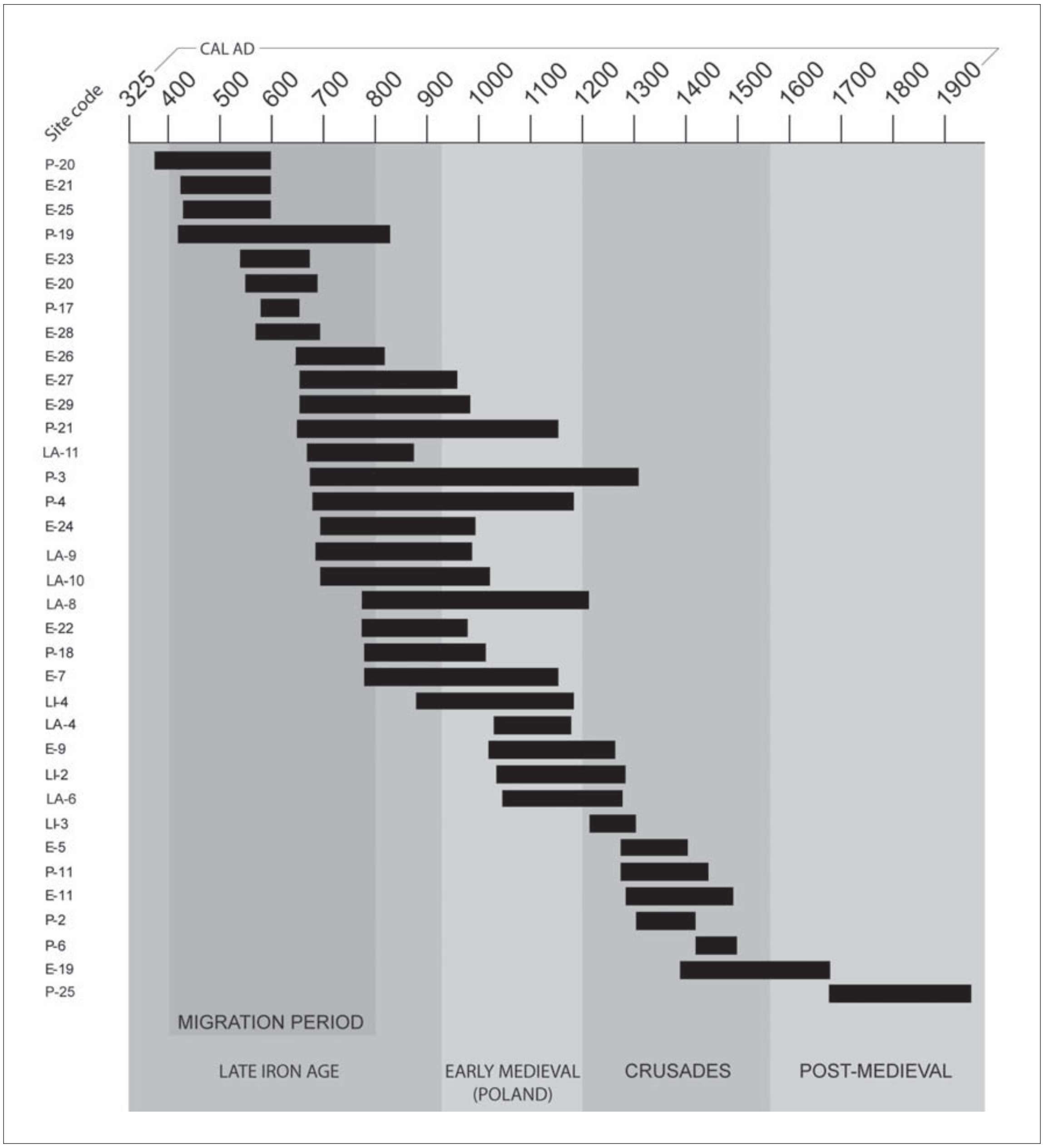

Fig. 3. The plot of the calibrated date ranges for pollen sequences with single radiocarbon dates ≤ 1500 14C years BP in relation to the principal archaeological periods (prepared by authors).

age of the Late Iron Age and medieval periods (Fig. 4). However, of the 36 sequences with multiple 14C dates, only 20 include three or more 14C dates (Fig. 2) that enable the development of more detailed depositional models. Although many sequences may show similar patterns of vegetation change, whether poorly dated or not dated at all, the lack of chronological context only serves to dilute the pattern apparent in those sequences where a clear chronological context can be established. The general caveat advocated here, therefore, is to avoid applying greater levels of chronological precision to vegetation changes than the 14C dates allow, irrespective of sample interval.

The pollen sequences derive from a range of depositional contexts (Appendix); the majority are from mires (37) and lakes (27), but with a small number from river flood plain (two), deltaic (one) and lagoon-shore (two) environments, as well from on site cultural layers (two) and buried soils (one). Differences in depositional context affect the taphonomy of the pollen record, but also the relative source area of pollen. The latter is very much linked to the size of the depositional basin; the smaller the basin, the smaller the relative source area (RSA) for pollen. Although the relationship is non-linear, computer simulation techniques increasingly allow for refined statistical estimates of RSA range (see Gaillard *et al.* 2008; Hellman *et al.* 2009). Smaller

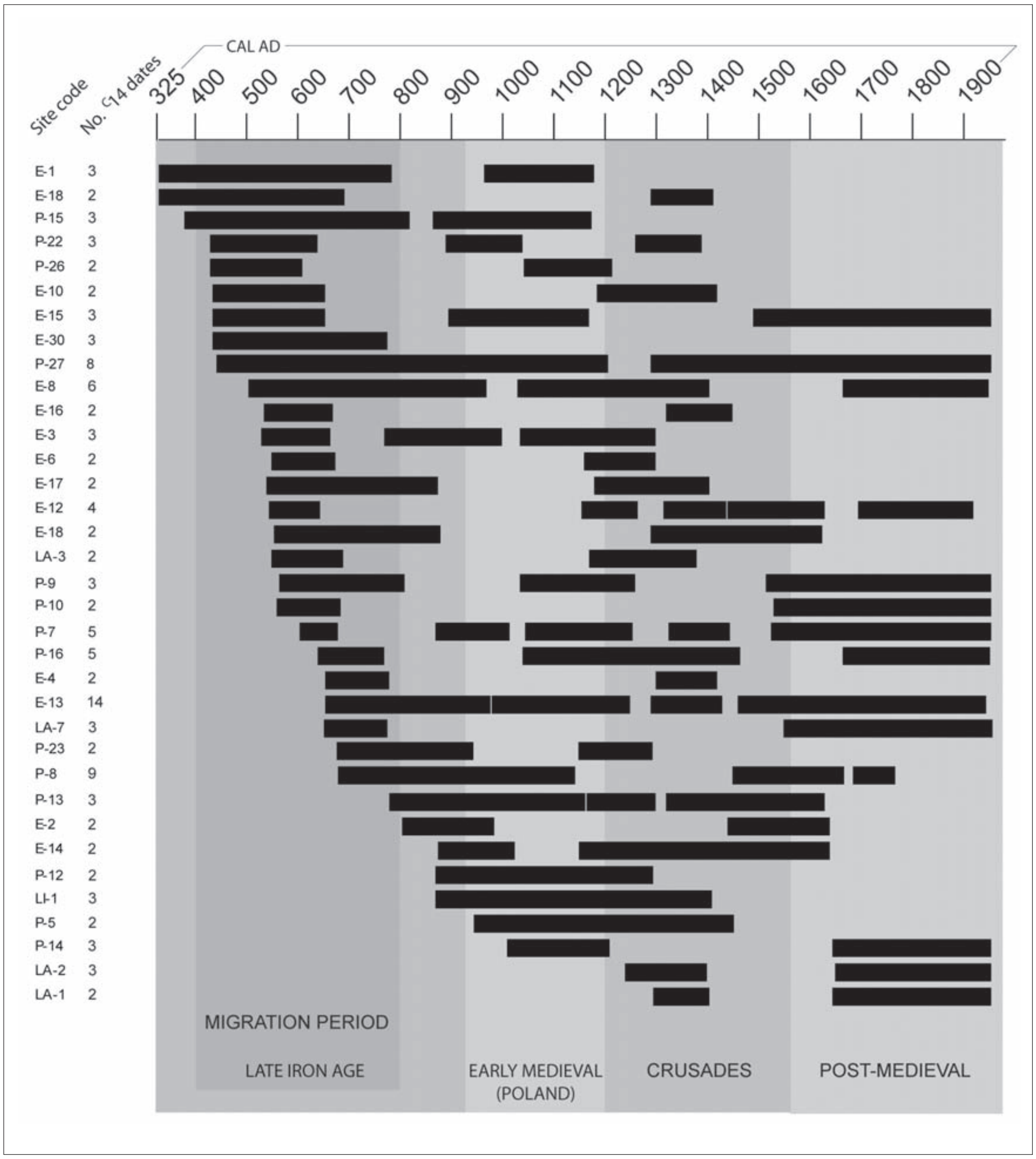

Fig. 4. The plot of the calibrated date ranges for pollen sequences with multiple radiocarbon dates ≤ 1500 14C years BP in relation to the principal archaeological periods (prepared by authors).

depositional basins are therefore better for studying local vegetation changes; larger basins will increasingly reflect the regional pollen catchment.

The type of depositional basin and location of pollen core are also important in detecting evidence of human activity. Anthropogenic signals are typically stronger in lake cores where cultivation results in the increased erosion and input of soils and sediments from surrounding fields. By comparison, people generally avoided bogs, and although they may have cultivated suitable surrounding land, the *in situ* vegetation of the bog surface acts both as a physical barrier impeding the effective dispersal of pollen from the adjacent dry ground, and in producing pollen which further dilutes the cultural signal. The strongest cultural signals are therefore present in pollen cores closest to the interface between bog and dry ground, where the filter effect of the wetland vegetation is weakest, and where agricultural sediments may erode into the bog-edge; cultural signals become progressively weaker further into the bog or as the bog expands. The filter effect also applies in situations where lakes are surrounded by thick vegetation, but the effect is less pronounced where lakes are foci for human activity, or where inflowing streams bring sediment containing pollen from the surrounding catchment.

Riverine, estuarine and lagoon sediments, by comparison, will include pollen transported over perhaps considerable distances, including from sediments and soils of both Holocene and pre–Holocene age within their respective fluvial catchments. The water bodies of estuaries and lagoons will also include a reservoir of pollen that may have been held in suspension for many years (Dark, Allen 2005). Pollen within cultural layers, including buried soils, may also be mixed or percolated down through a soil/sediment profile as a result of both bioturbation (e.g. earthworm activity and rooting) and anthropogenic processes. The latter may introduce pollen from sources related to very specific activities, for example, organic additions to soils (e.g. manure), food waste and pollen contained within materials transported to the site from varying distances.

Prussia (Fig. 5)

The Kulmerland

The early crusades during the first half of the 13th century were focused on the Kulmerland, representing an active frontier region between the expanding Teutonic state and the Kingdom of Poland. Prior to the crusades, the Kulmerland was a contested zone between Polish magnates and Prussian tribes, and witnessed active Slavic colonisation from the tenth century. The region thus witnessed two phases of colonisation, from the tenth and 13th centuries.

Pollen sequences from the Kulmerland, in common with much of northern Poland, show a predominantly wooded environment during the preceding late Iron Age, characterised by hornbeam-oak (*Carpinus-Quercus*) dominated woodland. Hornbeam in particular reaches its highest Holocene pollen values from ca. 1500 BP (fifth to seventh centuries), at a time of general forest regeneration during the Migration Period (Ralska-Jasiewiczowa *et al.* 2004b), but subsequently declines in importance by about the tenth century. Pollen data from Linje mire (P–5; Noryśkiewicz 2005), Chełmno/Rybaki (P–15; Noryśkiewicz 2004a), Uść (P–16; Noryśkiewicz 2004b) and Radzyń Chełminski (P–22; Wynne 2011) show a consistent picture of declining woodland, associated with a rise in pollen taxa indicative of increasing human impact from around the tenth century. This is typically characterised by the start of a continuous cereal pollen curve, and an increase in herbaceous pollen taxa strongly associated with human activity, including plants such as cornflower (*Centaurea cyanus*), a weed typically associated with cultivation, and which has been argued to reflect the presence of permanent rye fields (Vuorela 1986). At Linje mire and Radzyń Chełminski, this horizon produced similar dates of 1015±50 BP (Gd–15645, cal. AD 943 to 1155, Noryśkiewicz 2005) and 1035±30 BP (GU–24507, cal. AD 890 to 1040, Wynne 2011). At Uść however, the increase in anthropogenic indicators occurs midway between two closely spaced dates of 1340±35 BP (Poz–3633, cal. AD 640 to 772) and 830±70 BP (Ki–10270, cal. AD 1040 to 1281, Noryśkiewicz 2004b), whilst at Chełmno/Rybaki the increase in cereal pollen occurs between dates of 1360±70 BP (Ki–9673, cal. AD 640 to 772) and 1030±70 BP (Ki–9672, cal. AD 863 to 1175, Noryśkiewicz 2004a). Similar increases in the pollen of cereals and weeds and taxa characteristic of pasture and disturbed land are also apparent in nearby sequences from Czystochleb (P–19), dated prior to 1250±120 BP (cal. AD 425 to 829), and Napole (P–3), prior to 959±190 BP (cal. AD 675 to 1310), but in both cases the pollen data lack chronological precision due to the single dates and large uncertainties; neither sequence includes subsequent dates within the medieval period (Filbrandt-Czaja, Noryśkiewicz 2003). The significant levels of early medieval woodland clearance, yet relatively small increase in cereal pollen compared to the later medieval period, have led to suggestions that communities may have been cultivating more millet (*Panicum*) in the early medieval period (Latałowa, personal communication), with rye (*Secale*) becoming more popular in the later medieval. The dominance of millet over other cultivated plants in archaeobotanical samples from early medieval urban contexts, including Gdańsk (Badura 2011), emphasises its importance at this time, yet it is palynologically invisible, as its pollen is indistinguishable from that of grass. The top of the Chełmno/Rybaki sequence pre-dates the crusades, but at all the other sequences there is a second increase in cultural indicators, with a marked intensification in cereal cultivation, particularly rye, dated at Linje mire to 670±110 BP (Gd–16255, cal. AD 1153 to 1448), Radzyń Chełminski to 690±30 BP (GU–24506, cal. AD 1260 to 1390), and at Uść after 830±70 BP (Ki–10270, cal. AD 1040 to 1281). These two phases of intensifying human activity, although poorly resolved chronologically, could thus be argued to relate to Slavic and Germanic colonisation occurring from the tenth and 13th centuries respectively. Subsequent fluctuations in cereal pollen values are apparent, which may reflect instability within this frontier zone.

Pomesania and Pogesania

The lower Vistula and its tributary the Nogat represented an active frontier zone between Slavic Pomeralia (eastern Pomerania) and Prussian Pomesania. Pomeranian settlements, strongholds and ceramics are recorded east of the Nogat in the 11th and 12th cen-

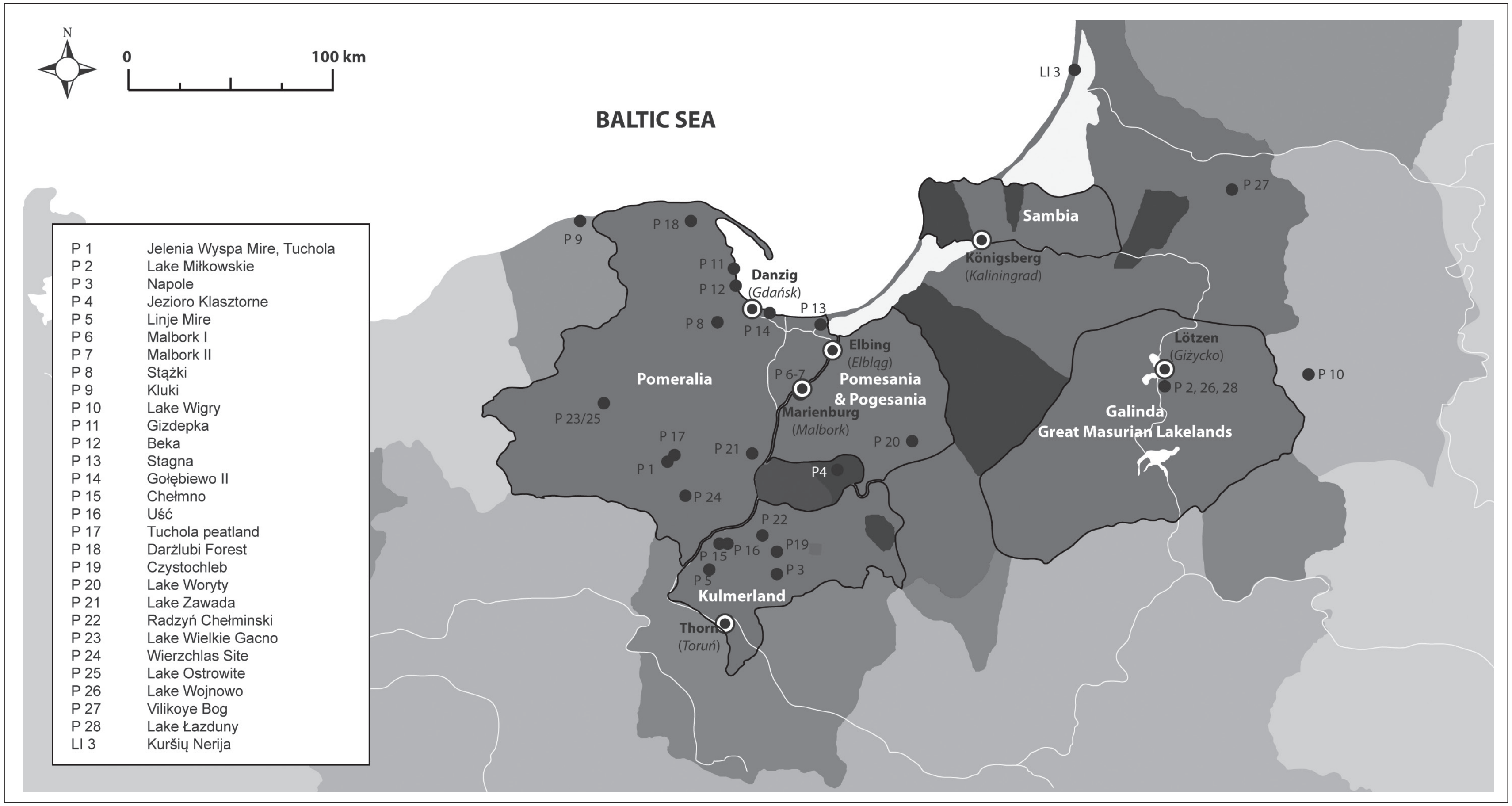

Fig. 5. The location of pollen sequences in Prussia (see Appendix for site name) (prepared by authors).

turies, followed in the early 13th century by Prussian expansion and the arrival in 1236 of the Teutonic Order moving north from the Kulmerland. Despite the concentration of pollen diagrams within the Vistula basin (Ralska-Jasiewiczowa *et al.* 2004a, Fig. 107), few of these sequences include deposits with associated radiocarbon dates ≤ 1500 14C years BP (Fig. 5).

However, a pollen core three kilometres south of Malbork (German Marienburg) (P–7) produced evidence for the significant clearance of woodland and agricultural intensification during the medieval period. Although the sediments are highly compressed, the start of a continuous rye pollen curve is dated 865±30 BP (Wk–24853, cal. AD 1040 to 1260) with values increasing significantly by 515±30 BP (GU–20433, cal. AD 1320 to 1450), coinciding with the construction and expansion of the castle at Malbork (Brown, Pluskowski 2011). Additional pollen cores from the Malbork commandery landscape will further elucidate the nature of vegetation changes during the medieval period. Several cores, currently under analysis by the author, have been taken from within and along the margins of the forest of Sztum; an area of extant woodland that documentary sources suggest remained wooded and was surrounded by several medieval settlements and manors. Initial assessment of pollen cores support the view that the woodland survived large-scale clearance, parts of which may also have been managed as an important resource, as documentary sources suggest (Chęć, Gancewski 2009).

Further to the east, pollen analysis from Lake Druzno, although undated beyond 6440±50 BP, shows two sequential phases of increasing woodland clearance and agricultural intensification within the top metre of sediment (Zachowicz *et al.* 1982; Zachowicz, Kępińska 1987) similar to that seen in sequences from the Kulmerland. The first phase follows the characteristic decline in hornbeam, well dated in other pollen sequences to around the tenth century, with the second phase characterised by an additional increase in the pollen of cereals and ruderals. The location of the sequence is significant, being in close proximity to the important early medieval (ninth to 12th century) trading emporium of Truso (Buko) and the Teutonic Order town of Elbląg (Fig. 1), administrative headquarters of the Teutonic state, and an important centre in the grain trade (Hybel 2002). Plant macrofossil analysis from urban deposits in Elbląg produced few actual cereal remains, but did include significant quantities of weeds associated with millet and root crops (Latałowa *et al.* 2003).

Pomeralia (Eastern Pomerania)

There are several radiocarbon-dated pollen sequences to the west of the Vistula within Pomeralia (Fig. 5), concentrated in the Tuchola region and along the Baltic coast, with several unpublished and ongoing sequences from Gdańsk and its hinterland (Latałowa, personal communication). The pollen evidence from Pomeralia suggests phases of increasing human impact during the early medieval period, which can be related to archaeologically and historically attested phases of Slavic settlement. The region did not come under the control of the Teutonic Order until 1309, although there is significant variation apparent in the pollen evidence.

Studies within the Tuchola National Park at Tuchola Peatland (P–17) suggest an increase in cereals and anthropogenic indicators from ca. AD 1000 (Lamentowicz *et al.* 2008b), although the horizon is poorly dated, with a more substantial increase in rye pollen values in subsequent centuries. Pollen analysis from the Wierzchlas site also shows an increase in cereal pollen from around the tenth century, with a later undated intensification (Pidek *et al.* 2009). A nearby pollen study from Jelenia Wyspa (P–1) likewise shows a small increase in cereal pollen from ca. AD 1000, with the start of a continuous rye pollen curve in the 15th century, but only increasing substantially more recently, within the last 150 years (Lamentowicz *et al.* 2007). However, pollen data from Lake Wielkie Gacno (P–23) show a significant drop in arboreal pollen and an increase in cereal pollen from the eighth century, with a distinct increase in human influence from the late tenth century, followed by increasing grazing indicators from AD 1300 (Hjelmroos 1981). Nearby sequences at Lake Maly Suszek, Suszek and Lake Kęsowo exhibit similar pollen profiles, with evidence of significant woodland clearance and agricultural expansion, dated by comparison with the Lake Wielkie Gacno sequence to the medieval period (Miotk-Szpiganowicz 1992; Berglund *et al.* 1993). The Kęsowo sequence in particular is argued to show a clear increase in cereals from the 11th century, intensifying through the 12th to 16th centuries, with the almost complete disappearance of oak-hornbeam-dominated deciduous woodland around AD 1200, with further intensive clearings in the 14th and 15th centuries (Miotk-Szpiganowicz 1992). The evidence for intensifying human impact in the Lake Wielkie Gacno, Kęsowo, Maly Suszek and Suszek pollen sequences is mirrored by an increase in archaeological evidence of human settlement of medieval date in the region. There is a dense distribution of both early medieval open settlements and fortified strongholds from the ninth to the 12th centuries, as well as settlements from the 13th century (Miotk-Szpiganowicz 1992, Fig. 7).

Further to the north at Stazki mire (P–8), located within the Kaszuby lakelands, pollen of rye and wheat (*Triticum*) are present, although in small quantities, from the base of the sequence dated ca. AD 800, but do not increase, along with other anthropogenic indicators, until the early 16th century (Lamentowicz *et al.* 2008a). In addition, there are several pollen sequences with medieval-dated deposits along the Baltic coast west of Gdańsk (Danzig). Although of low chronological and sample resolution, pollen data from Gizdepka (P–11) and Beka (P–12) show an increase in wet meadows, with an associated increase in cereal pollen during the medieval period. This is dated at Gizdepka just prior to 600±75 BP (cal. AD 1276 to 1438), and at Beka from 980±100 BP (cal. AD 868 to 1263), although the Beka sequence does not extend beyond 885±105 BP (cal. AD 966 to 1293) (Miotk-Szpiganowicz *et al.* 2010). Pollen data from Gołebiewo (P–14), located a few kilometres west of Gdańsk, shows large-scale deforestation of oak-hornbeam forests from the tenth and 11th centuries, associated with the development of early medieval Gdańsk (Latałowa *et al.* 2009). Archaeobotanical samples from both early and later medieval contexts within Gdańsk indicate that millet was the most prevalent cereal in the early medieval period, with rye and wheat becoming the most popular cereals in the later medieval period (Badura 2011). From the 14th century, Gdańsk developed into a major transit port for the export of grain, chiefly rye, throughout the Baltic and the North Sea, becoming the foremost economic power in the Baltic by the 15th century. The economic status of Gdansk is further emphasised by the numerous finds of exotic plants, reflecting the wealth of the city burghers, who must have consumed some of these.

The Great Masurian Lakelands

The landscape of northeast Prussia is characterised by numerous connected lakes, rivers, streams and marshes, surrounded by broad swathes of woodland. Paradoxically, despite the palynological potential and numerous pollen studies of the many lakes and bogs (e.g. Wacnik, Madeyska 2008), this vast area is the least well supported by relevant pollen data on the Late Iron Age and medieval period; only three studies, Lake Miłkowskie (P–2; Majeda *et al.* 2010), Lake Wojnowo (P–26, Wacnik 2009) and Lake Wigry (P–10; Kupryjanowicz 2007), have accompanying 14C dates ≤ 1500 14C years BP. In other cases, it is apparent that more recent organic deposits have been lost or degraded, perhaps as a result of peat cutting or agricultural drainage. For example, the top of the sediment profile of the former Lake Staświńskie, a large mire system located about two kilometres to the east of Lake Wojnow, dates from the early medieval period at the very latest (Wacnik, Ralska-Jasiewiczowa 2010; Wacnik, personal communication).

Prior to the crusades, Prussia was inhabited by several tribes, including the Galindians within the Great Masurian Lakelands. The territory of Galindia is described by Peter of Dusburg as '*terra desolata*' (desolate land), specifically recounting the destruction of the Galindians by a neighbouring tribe (of unknown name), resulting in a depopulated wilderness (Nowakiewicz, Wróblewski 2003). Much the same description of the landscape applies to Sudovia, located to the east, inhabited by a powerful Prussian tribe (Sudovians), defeated by the Teutonic Order in 1283. Following their defeat, the remaining Sudovians were resettled to the west, apparently leaving a depopulated country that developed into an extensive wooded wilderness, a formidable natural barrier separating Teutonic Prussia from Lithuania (Urban 2003). The area remains an unstable military frontier throughout the 14th century, with only limited colonisation before the 15th century.

However, pollen analysis from Lake Wigry, located at the boundaries of Galindia and Sudovia, indicates the regeneration of woodland in the second half of the first millennium AD, with decreasing levels of human indicators, a picture at odds with the archaeological evidence for intensive colonisation at this time (Kupryjanowicz 2007). Moreover, the subsequent phase (cal. AD 1274 to 1601) is characterised by decreasing woodlands and an increase in cereal cultivation, including rye and buckwheat, again at odds with archaeological evidence that the area was uninhabited between the 13th and 15th centuries.

Pollen analysis from Lake Miłkowski also seems to contradict the 'desolate land' description of Galindia by Peter of Dusburg. There is rapid and almost complete deforestation of the lake catchment from cal. AD 1000 to 1150, with intensive cultivation of cereals, hemp (*Cannabis sativa*) and buckwheat (*Fagopyrum esculentum*) in the 13th century (Majeda *et al.* 2010). The ecological signature is repeated to the north at Lake Wojnowo, likewise showing evidence of substantial deforestation and cultivation (Wacnik *et al.* 2012). Importantly, Lake Wojnowo is located below the Prussian stronghold of Swięta Góra, where recent excavations have produced cultural material from pits demonstrating settlement continuity from Prussian to Teutonic periods; a situation unique in the region, as all other tribal strongholds have failed to produce cultural material beyond the 13th century (Karczewski *et al.*, forthcoming). The apparent contradiction between pollen and documentary sources emphasises the potential dangers in generalising entire regions from often localised sources of data, and instead underlines the importance of developing a more nuanced picture of land use. Whilst the chronicles of Peter of Dusburg record the destruction of many tribal strongholds, in cases supported by archaeological data, it is equally clear from the Lake Miłkowskie and Wojnowo pollen sequences, and excavations at Swięta Góra, that pockets of settlement continued into the 14th century and beyond.

Livonia (Fig. 6)

Southern Livonia (Latvia) and Samogitia (northwest Lithuania)

The Livonian crusade began with the conquest of the Livs and Latgalians (1209 to 1227) (eastern Latvia) by the armies of the Bishops and Sword Brothers (the Livonian Order after 1237); and later, following the conquest of Estonia, by partially successful crusades in western Latvia (1219 to 1290), resulting in the subjugation of Curonia and northern Semigalia. Samogitia remained unconquered, forming contested territory between Livonia and the Grand Duchy of Lithuania.

Although research into the Holocene vegetation history of Latvia has taken place since the early 20th century, the Late Iron Age and medieval periods are poorly supported by well-dated pollen studies (Fig. 6; Appendix). The evidence from the small number of 14C dated pollen sequences suggests only intermittent and small increases in pollen taxa indicative of human activity at this time, despite the archaeological and historical evidence that the Late Iron Age in the east Baltic was a period of demographic and economic expansion (Kihno, Valk 1999).

Most pollen diagrams suggest that tree pollen does not decline significantly until perhaps the end of the 15th century. Written sources suggest that there was little management of Latvian woodlands, with no evidence of coppicing, whilst many sacred forests, mainly oak and lime (*Tilia*), were tolerated by the Order until the arrival of the Jesuits in the 16th century (Kļaviņš 2011). However, written sources relating to Riga indicate that there was a lack of timber resources in the surrounding region by AD 1255, with a subsequent increase in the exploitation of woodlands along the Dauga River and its tributaries. Oak wainscots (high-quality timber boards) are also recorded as an important export from Riga (Zunde 1998/1999), although woodland exploitation appears to have been limited in extent beyond Riga. Pollen analysis from Eipurs and Dzelve-Kronis bogs (La–2–3; Kušķe *et al.* 2010) show only small increases in pollen indicative of pasture/meadow and arable land during the medieval period, at Eipurs bog from a level dated 689±50 BP (cal. AD 1228 to 1398) and at Dzelve-Kronis bog after 757±55 BP (cal. AD 1169 to 1381), in both cases following the crusades. Indications of human activity are likewise sparse from Nineris mire (La–1), three kilometres north of the headquarters of the Livonian Order at Cēsis, with preliminary analysis suggesting little or no cereal cultivation in the vicinity of the mire before 205±30 BP (GU–23349, cal. AD 1640 to 1960). An earlier although small increase in pasture and arable land was recorded in the Lake Kūži (La–4) sequence from a level dated 925±30 BP (cal. AD 1029 to 1180, Kangur *et al.* 2009). In eastern Latvia, pollen analysis from Lake Kurjanovas (La–7) produced evidence of an increase and continuous curve in cereal pollen from the Bronze Age, with an increase in rye, albeit intermittent, from around the tenth century (Heikkilä, Seppä 2010).

In northeast Lithuania, a reduction in woodland and an increase in agricultural activity of Late Iron Age date is apparent in pollen sequences from Lake Biržulis (Li–2; Stančikaitė *et al.* 2006), the Baltija Uplands (Li–4; Stančikaitė *et al.* 2004) and from Impiltis Iron Age hill-fort on the Curonian coast (Li–1; Stančikaitė *et al.* 2009), followed by a regression in human activity during the medieval period. This is most obvious from Impiltis, where there is significant woodland regeneration and a reduction in agricultural activity from ca. AD 1250, which is argued to reflect the changing social and political situation in Curonia at this time (Stančikaitė *et al.* 2009); the area remained an active frontier zone between Livonia and Lithuania into the 16th century. Written sources nonetheless show that Lithuanian timber was being exported to Königsberg and Danzig from the early 15th century, increasing after the defeat of the Teutonic Order at Grünwald in 1410, but that Lithuanian woodlands were most extensively exploited from the mid-16th century (Pukienė, Ožalas 2007).

Northern Livonia and the Duchy of Estonia (Estonia)

The conquest of northern Livonia took place on multiple fronts; the Sword Brothers were engaged in a protracted and bloody crusade in southern Estonia (1208 to 1227), whilst the Danes invaded northern Estonia (1219), and the Swedes unsuccessfully invaded western Estonia (1220). Although northern Estonia was briefly conquered by the Sword Brothers, it was ceded back to the Danish crown (the Duchy of Estonia), but was later annexed by the Teutonic Order in 1343. Saaremaa, inhabited by the Osilians, was only conquered in 1261, after several unsuccessful attempts

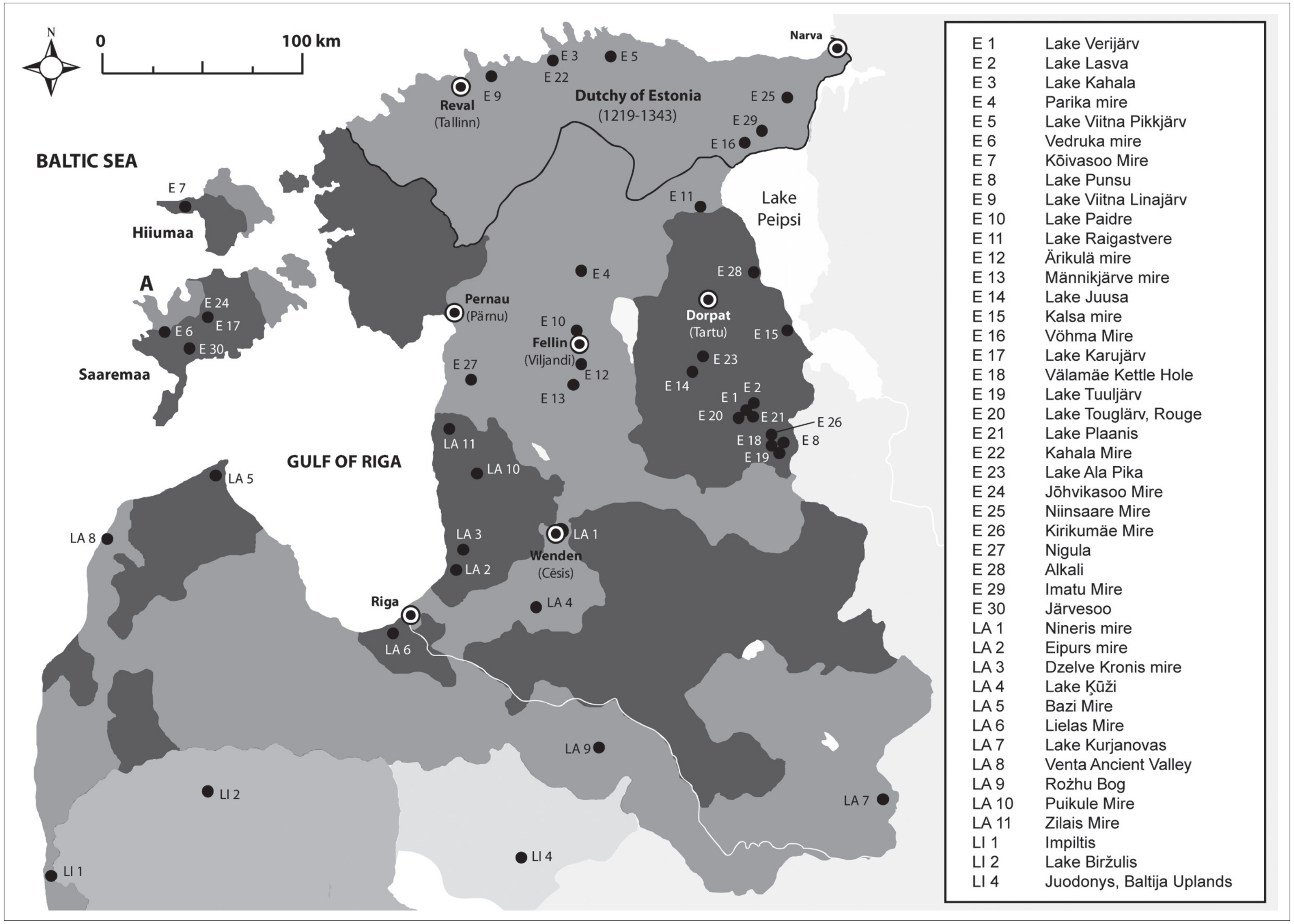

Fig. 6. The location of pollen sequences in Livonia and adjoining territories (see Appendix for site name) (prepared by authors).

by Denmark, the Livonian Order and the Bishopric of Ösel Wiek to subdue and Christianise the island.

During the Late Iron Age (AD 800 to 1300), Saaremaa is argued to have been the most developed part of Estonia, perhaps in part as a consequence of contacts with Scandinavia and its favourable position on the Baltic-Black Sea trade route. Documentary sources highlight the increasing power of the Osilian navy during this time (Magi 2004). The archaeological material points towards rapid development from the tenth century, with the Danish book of land taxation (*Liber Census Daniæ*) listing 3,000 farmsteads by AD 1300 (Ligi 1992). Several pollen studies from across Saaremaa demonstrate increasing human impact on the landscape during the Late Iron Age (ca. AD 800 to 1300). At Surusoo and Vedruka mire (E–6), peaks in rye, barley (*Hordeum*) and cornflower suggest the existence of permanent arable fields from around AD 850 (Poska, Saarse 2002), with a small peak in cereal pollen at Jõvikasoo mire (E–24) dated to between the eighth and tenth centuries (Hansson *et al.* 1996). Subsequent increases in cereal pollen, particularly rye, are apparent in all three sequences. Only at Vedruka mire has this been radiocarbon dated, producing a date of 590±30 BP (Ta–2572, cal. AD 1307 to 1403; Poska, Saarse 2002), perhaps suggesting an increase in cultivation following the final conquest and Christianisation of Saaremaa. However, there is little or no evidence for agricultural activity in pollen sequences from lakes Järvesso (E–30) or Karujäva (E–17) (Saarse, Königsson 1992). As a whole, the medieval period on Saaremaa remains poorly supported by well-dated pollen sequences, whilst archaeobotanical studies are largely limited to urban contexts from mainland Estonia.

Pollen studies from the north coast of Estonia (Fig. 6; Duchy of Estonia) likewise suggest an increase in agricultural activity during the Late Iron Age, intensifying in the medieval period, although the chronological resolution of the pollen data remains an issue. Pollen studies from Kahala (E3, E22) show continuous values for cereal pollen from AD 700, and rye from AD 850, the latter peaking in value around AD 1200. Documentary sources record the presence of three villages and 40 plots of arable land in the Kahala region in AD 1240 (Poska, Saarse 1999). Rye pollen also increases in sequences from Lake Viitna Linajärv (E–9) from 885±70 BP (cal. AD 1010 to 1265, Punning *et al*. 2007) and Lake Viitna Pikkjärv (E–5) dated to 650±45 BP (Tln–2141, cal. AD 1275 to 1400). Estimated dates for increases in cereal cultivation are also proposed for pollen sequences close to Tallinn, including from Lake Maardu around AD 1000 and 1300, perhaps associated with an increase in village settlements and the development of rotational field systems recorded from the 11th century (Veski, Lang 1996). Likewise, from nearby Tondi mire, there are indications of agricultural intensification from both the Viking Age and the medieval period, the latter archaeologically well-attested to, with 13 farms and villages from the 13th century recorded in the vicinity of the mire (Lang, Kimmel 1996; Kimmel *et al.* 1996).

In southern Estonia, pollen studies likewise indicate the cultivation of a range of crops throughout the Viking Age and the Late Iron Age, including rye, wheat, cannabis and flax (*Linum usitatissimum*). For example, pollen from Lake Verijärv (E–1) shows a continuous cereal curve from the seventh century, with a continuous increase in wheat from cal AD 1250 (Niinemets, Saarse 2009), whilst there is an increase in cultivated land from the eighth century onwards from Lake Ala-Pika (E–23) (Kihno, Valk 1999). However, it is apparent from other pollen sequences that agricultural intensification occurs only after the crusades/conquest, or is accompanied by fluctuations in cereal pollen resulting from the impact of warfare or as a consequence of disease, famine or climate.

Pollen within varved sediments from Lake Tõugjärv (E–20) shows a generally wooded landscape prior to AD 1200, but with an increase in agricultural activity apparent only from AD 1350 (Veski *et al.* 2005). The surroundings of Lake Lasva (E–2) were likewise densely forested between AD 1000 and 1150, with extensive arable farming occurring only after the conquest, with a large increase in charcoal and pollen from grasses and a range of cereal pollen. A subsequent decline in cereal pollen during the 14th century is argued to reflect the impact of the Black Death (Niinemets, Saarse 2009; Niinemets 2010). From Ärikulä mire (E–12), a continuous cereal pollen curve does not occur until the level dated 540±30 BP (Gu–23343, cal. AD 1316 to 1437). Interestingly, at Parika mire (E–4), an increase in agricultural activity from AD 1100 is followed by a small decline in cereal pollen at the end of the Iron Age, disappearing completely in about AD 1200 to 1250, only to reappear later. The collapse in arable farming is ascribed to the effects of both battles and plagues (Niinemets *et al.* 2002).

In the majority of the above cases, arable farming does not appear to intensify/re-intensify until the 14th century, although there are obvious problems in relating historically documented events with, in cases, poorly chronologically resolved pollen data. The first decades after the conquest probably saw no major changes in everyday life; there was limited colonisation beyond the towns and castles, and it took most of the 13th century to fully conquer and stabilise the territory of Estonia. However, it is possible to hypothesise that the increase in cereal pollen during the 14th century may be linked to increased political stability, the growth of urban centres, the growing significance of the Hanseatic League and foreign trading networks, and the establishment of serfdom, creating an increased demand for agricultural produce (Raun 2002; Kala 2005). The importance of agricultural produce, particularly rye, is demonstrated not only from the pollen record, but also through documentary and archaeobotanical evidence for its significance as a consumable, tradable and taxable commodity. Remains of rye, along with barely, are typically the most important cultivated plants within archaeobotanical samples in urban contexts from Tallinn, Tartu, Pärnu and Viljandi. Lesser quantities of wheat, millet and buckwheat are also recorded, along with a range of legumes, wild and exotic plants (fruits, spices and oil/fibre plants), the latter reflecting the development of longer-distance trade routes (Sillasoo, Hiie 2007).

Discussion and conclusions

The medieval period, dominated by the crusading movement, witnesses a significant change in the ownership, organisation and administration of the landscape, with significant changes in patterns of land use from the preceding Late Iron Age. These changes cannot be characterised in the same manner or intensity across the entire Baltic region. The timing and the scale of human impact result from a complex interrelationship between changes in political geography and patterns of warfare and colonisation across the Baltic, combined with variations in vegetation, topography, population density and the agricultural capacity of the landscape. Differences in the temporal and spatial impact of human activity are apparent in the pollen record both within and between Prussia and Livonia, although variations in chronological resolution and pollen coverage between regions place unavoidable limits on the details of these observations and comparisons.

However, two broad observations can be made: that these woodlands came under increasing human impact from the Late Iron Age as a consequence of demographic and economic expansion, and that this occurs most intensively within Prussia rather than Livonia. In addition, it is also possible with the pollen data to differentiate broadly between intensively colonised ‘heartland’ areas, and sparsely populated ‘frontier’ areas, where the effects of the crusades result in contrasting patterns of agricultural intensification and landscape regression.

One of the key defining features of the medieval period in the Baltic is the appearance of towns and castles and new forms of organisation and administration of the landscape. Towns became new centres for food consumption and trade, whilst the castles and manors of the Order and the bishops earned revenue in part through taxing local agricultural produce. Demographic and economic expansion created increased demand for agricultural produce, as a consumable, taxable and tradeable commodity. The impact on woodland resulting from the increased requirement for constructional timber must also have been considerable, particularly around the main urban centres and castles; many of the early buildings would have been constructed of timber before being replaced or augmented by brick.

In Prussia, human impact is most apparent in the pollen record from the Vistula basin, associated with extensive Slavic and Germanic colonisation from around the tenth and 13th centuries respectively. This no doubt has much to do with the importance of the Vistula and its tributaries as key arteries for trade and communication linking the Polish and Prussian hinterlands with the Baltic Sea. The crusades follow the course of the Vistula, and estimates suggest that by the beginning of the 14th century, the population of Prussia stood at around 220,000 (Biskup 2002), concentrated most densely around the many towns and castles extending from Thorn (Toruń) in the south to Danzig (Gdańsk) in the north. By comparison, the eastern regions of Prussia, such as Masuria, were more sparsely populated, and witnessed significant disruption of indigenous settlement patterns as a result of the crusades, with only limited colonisation until the 15th century. However, the environmental context for the Late Iron Age and medieval periods is poorly resolved. The focus of existing pollen studies is not restricted to the late Holocene, and although pollen data suggest a broad measure of continuity in land use (e.g. Madeja *et al.* 2010 ; Wacnik *et al.* 2012), the extensive pollen source area of these lakes may reflect the average human impact over a larger area. Targeted fine-resolution pollen analysis, for example of smaller peat and lake deposits, may help in providing more localised comparative pollen data on potential variability in land use. Does this support the archaeological picture of widespread settlement discontinuity in the 13th century? And is this followed by evidence for renewed agricultural intensification accompanying colonisation in the 15th century?

In contrast, the Sambian Peninsula to the north (encompassing the Kaliningrad Oblast) was one of the more densely settled parts of Prussia. Sambia was a major cultural and economic power from the eighth century, before being virtually destroyed by the crusaders and further assimilated by subsequent Germanic colonisation. Königsberg thereafter emerges as a major trading centre from the 14th century. However, the region represents a virtual blank on distribution maps of pollen studies, although recently published pollen data from Velikoye bog (P27; Fig. 5) in northeast Kaliningrad (in Prussian Nadrowia) does point towards increasing human impact from around the ninth century (Arslanov *et al.* 2011). There is significant further potential, therefore, to investigate the comparative environmental impact of Iron Age and medieval cultures on the landscape of the Sambian Peninsula.

Livonia did not witness the same intensity of colonisation as Prussia; the population was sparser, and the extent of human impact was more localised around urban and rural centres. Human impact is most intensively seen on Saaremaa from the Viking Age, but the pollen record is poorly resolved for the medieval period. In northwest Estonia, there are indications of agricultural intensification during both the Viking Age and medieval periods, yet in southern Estonia there is evidence from several pollen sequences that this intensification does not occur until around the 13th or 14th century. The difference in pollen signals between north and south may reflect differences in settlement density, and the greater political, cultural and economic importance of the islands and northwest Estonia in the Iron Age. Further explanation for the difference in pollen signals may also lie in a border zone running southwest to northeast across Estonia, defining differences in physical geography and vegetation. This is most apparent in southwest Estonia, where a large belt of uninhabited bog and forest separates inland areas from the coast. This natural border zone also defines the border between medieval Estonia and the northern tip of Livonia, encompassing present-day southwest Estonia (Valk 2009). This border zone may have formed a natural barrier limiting communication and movement between the coast and the interior during the Iron Age, but that changed with the crusades. The location of other pollen sequences in marginal and otherwise sparsely settled areas may also explain why some sequences have weak anthropogenic signals.

Pollen evidence for the environmental impact of the crusades in Latvia (southern Livonia) is comparatively limited at present, although several pollen cores have recently been sampled by this author from within the Cesis commandery as part of the 'Ecology of Crusading' project. However, existing pollen studies along the Curonian coast, Semigalia and Samogitia suggest that the effect of the crusades was to create an unstable military frontier zone during the medieval period between Livonia and Samogitia/Grand Duchy of Lithuania, characterised by woodland regeneration rather than agricultural intensification. Palynological analysis within the Cesis commandery will therefore be important in comparing the ecological signals of a frontier and heartland area within southern Livonia.

It is perhaps no surprise from the pollen record, despite the evidence for agricultural intensification, that woodlands remain an important feature of Baltic landscapes, particularly within Livonia and the more sparsely populated frontier zones. Woodlands are equally important in understanding how societies perceived and exploited the landscape. Aspects of the natural world were especially sacred to Late Iron Age pagan communities across the Baltic, and written sources often refer to the cultural significance of sacred woodlands and trees (Kļaviņš 2011). Moreover, written sources demonstrate that the Order also recognised the importance of preserving and managing woodlands as a resource. For example, industrial processes, such as iron smelting and brick manufacture, the latter vital in Prussia in the absence of a suitable stone source, would have required significant quantities of charcoal for fuel, itself necessitating large volumes of wood, perhaps from managed sources.

However, it remains unclear whether timber requirements within commanderies were satisfied from the immediate landscape or from further afield. Much, no doubt, would have depended on the political geography, resources and provisioning networks within specific commanderies. For example, the forest of Sztum, located ten kilometres south of Malbork castle, is documented as actively managed woodland in the 14th and 15th centuries, although these sources lack precise details on the nature and the extent of this management. The analysis of written documents relating to the provisioning of specific castles may highlight potential timber sources. Detailed pollen analysis may reveal evidence for specific forms of management, perhaps visible as subtle changes in woodland composition. An initial assessment of pollen-bearing deposits within the forest of Sztum shows little evidence of woodland clearance, whilst the analysis of animal bones from nearby excavations at Biała Gora indicates the exploitation of a range of woodland and wetland species. The Teutonic Order clearly had the resources to transport materials over long distances. Documentary sources demonstrate that the provisioning network for castles extended across and beyond the Order's state. Written documents on the timber trade are rare before the 16th century, but some sense of scale is provided by documents showing that the Teutonic Order brought almost one and a half million pieces of timber between 1389 and 1415, mostly from Masovia, in the form of wainscots (high-quality timber boards). Large quantities of Baltic timber were exported to Western Europe; the principal source of this timber in the 14th century was from within the catchment of the lower Vistula, but

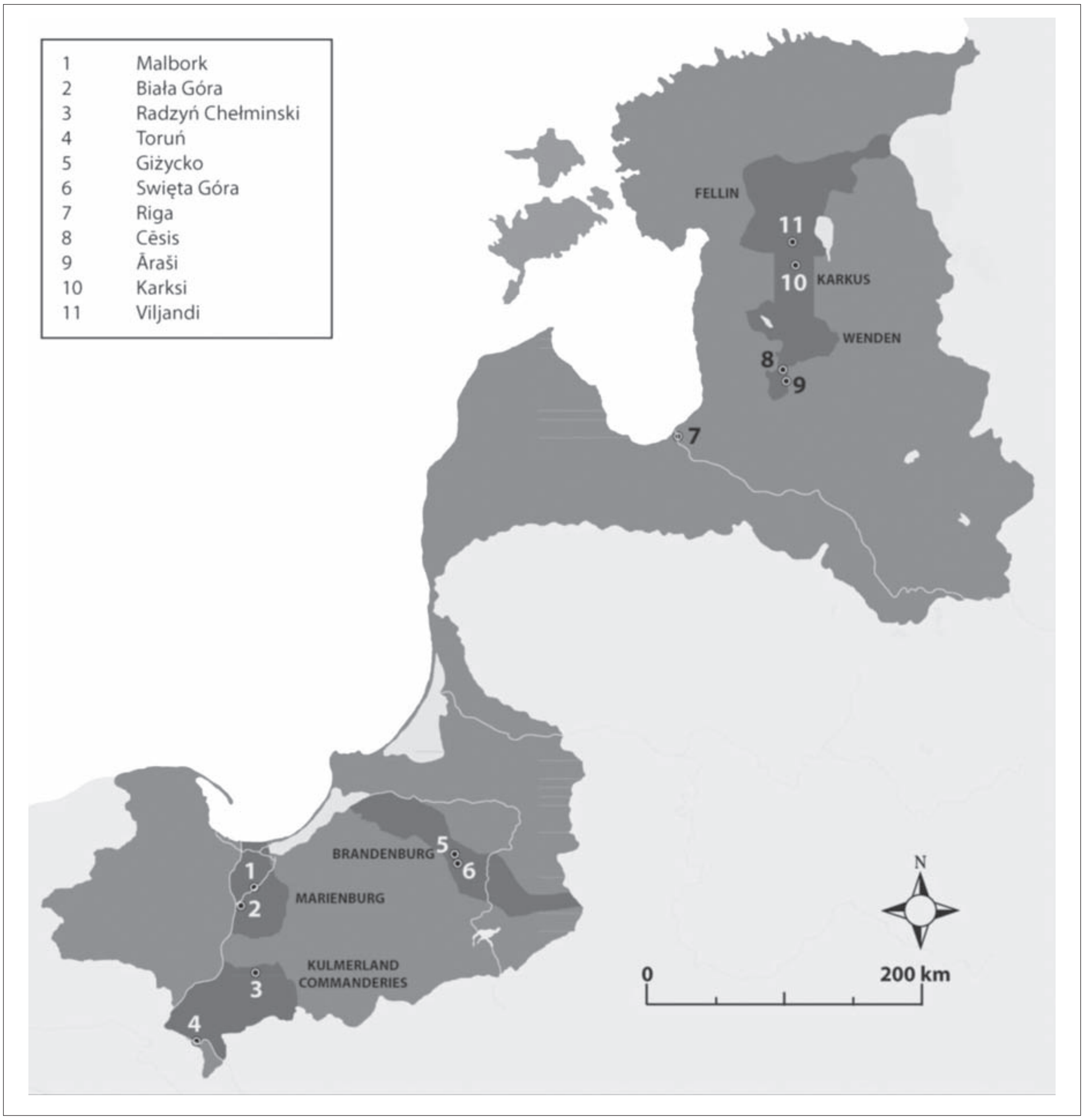

Fig. 7. The ecology of crusading macro-region case studies (shaded) (prepared by authors).

moved to Masovia in the 15th century as local timber supplies declined (Haneca *et al.* 2005; Ważny 2005).

The existing palaeoenvironmental record from the southeast and eastern Baltic raise several priority areas of potential research within the context of the 'Ecology of Crusading' project (see Pluskowski, this volume, p.7). An important methodological aspect of the project is the focus on the retrieval of a range of environmental data from archaeological excavations (Iron Age strongholds, the Teutonic Order's castles and urban sites) and the comparison with the longer-term palynological record from offsite contexts, i.e. bogs and lakes. A total of 29 pollen cores have thus far been sampled from across Prussia and Livonia, with further programmes of lake and peat coring planned. The coring has focused on a series of macro-regions relating to the commanderies of several Teutonic Order castles; Marienburg (Malbork) and Lötzen (Giżycko), Wenden (Cēsis), Karkus (Karksi) and Fellin (Viljandi) (Fig. 7). The object is to produce high-resolution palynological sequences covering the Late Iron Age to post-medieval periods that enable the detailed comparative analysis of the degree to which the crusades modified the landscapes of the southeast and eastern Baltic. The existing pollen record already highlights interesting differences in ecological signatures between the Iron Age/medieval periods, Prussia/Livonia, and heartland/frontier, which further pollen analysis can test and refine. Pollen analysis will be supported by an extensive programme of radiocarbon dating that will develop a robust chronological framework. This is essential if useful comment is to be made on patterns of vegetation change and human impact that are applicable to specific data from on-site contexts and of equal relevance in view of important contemporary cultural changes.

Each lake and peat core will also be analysed for the presence of microscopic particles of volcanic ash (crypto-tephra) ejected during Icelandic volcanic eruptions and transported in ash plumes across northern Europe. Over 200 eruptions have been identified in Iceland during the last 1,000 years (Wastegård, Davies 2009), but only comparatively recently has tephra been identified in the eastern Baltic. The analysis of cores from Mustjärve and Parika in Estonia, identified small quantities of crypto-tephra of mid-Holocene date that suggest that the eastern Baltic is at the very limits of Icelandic tephra distribution (Hang *et al.* 2006). Thus far, no late Holocene tephra has been identified in the eastern Baltic, although the preliminary analysis of cores from Radzyń Chełminski in Poland indicates the presence of potential tephra horizons of medieval date (Wynne 2011). The geochemical analysis of tephra from cores may show a correlation with known volcanic eruptions, identifying isochronous marker horizons that can assist in further developing and validating chronological models for palaeoenvironmental sequences. This may in practice prove more challenging, since it is often difficult to identify the source of tephra to specific eruptions (Wastegård, Davies 2009). The results of these analyses will be reported in due course.

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Appendix 1. Pollen sequences from the southeast and eastern Baltic, with associated radiocarbon dates ≤ 1500 14C years BP. (List of pollen studies complete as of 2012).

Site Code	Site Name	14C dates ≤ 1500 14Cyrs BP	Deposit type	References
		ESTONIA		
E-1	Lake Verijärv	3	Lake	Saarse, Niinemets 2007; Niinemets, Saarse 2009
E-2	Lake Lasva	2	Lake	Niinemets, Saarse 2006, 2007; Saarse, Niinemets 2007
E-3	Lake Kahala	3	Lake	Poska, Saarse 1999
E-4	Parika mire	2	Mire	Niinemets *et al.* 2002
E-5	Lake Viitna Pikkjärv	1	Lake	Saarse *et al.* 1998
E-6	Vedruka mire	2	Mire	Poska, Saarse 2002
E-7	Kõivasoo Mire	1	Mire	Königsson *et al.* 1998
E-8	Lake Punsu	6	Lake	Saarse, Rajamäe 1997
E-9	Lake Viitna Linajärv	1	Lake	Punning *et al.* 2007
E-10	Lake Paidre	2	Lake	Saarse *et al.* 1995
E-11	Lake Raigastvere	1	Lake	Seppä, Poska 2004
E-12	Ärikulä mire	4	Mire	Brown *et al.* (in print)
E-13	Männikjärve mire	14	Mire	Sillasoo *et al.* 2007
E-14	Lake Juusa	2	Lake	Koff *et al.* 2005; Punning *et al.* 2005
E-15	Kalsa mire	3	Mire	Kimmel *et al.* 1999
E-16	Vöhma Mire	2	Mire	European Pollen Database
E-17	Lake Karujärv	2	Lake	Saarse, Königsson 1992
E-18	Välamäe Kettle Hole (VI/VIII)	4	Mire	Punning *et al.* 1995
E-19	Lake Tuuljärv	1	Lake	Saarse *et al.* 1996
E-20	Lake Touglärv, Rouge	1	Lake	Veski *et al.* 2005; Saarse, Niinemets 2007
E-21	Lake Plaanis	1	Lake	Niinemets, Saarse 2009
E-22	Kahala Mire	1	Mire	Poska and Saarse 1999
E-23	Lake Ala-Pika	1	Lake	Kihno and Valk 1999
E-24	Jõhvikasoo Mire	1	Mire	Hansson *et al.* 1996
E-25	Niinsaare Mire	1	Mire	Koff 1996
E-26	Kirikumäe Mire (core 43)	1	Mire	Saarse, Rajamäe 1997
E-27	Nigula	1	Mire	European Pollen Database
E-28	Alkali	1	River-bank	Poska, Saarse 2006
E-29	Imatu Mire	1	Mire	Kimmel *et al.* 1999
E-30	Järvesoo	3	Mire	Saarse, Königsson 1992
		LATVIA		
La-1	Nineris mire	2	Mire	Brown Unpublished
La-2	Eipurs mire	3	Mire	Kušķe *et al.* 2010
La-3	Dzelve-Kronis mire	2	Mire	Kušķe *et al.* 2010
La-4	Lake Ķūži 1	1	Lake	Kangur *et al.* 2009
La-5	Bazi Mire	2	Mire	Pakalne, Kalniņa 2005
La-6	Lielas Mire	1	Mire	Kalniņa 2006
La-7	Lake Kurjanovas	3	Lake	Heikkilä, Seppä 2010
La-8	Venta Ancient Valley	1	Mire	Kalniņa *et al.* 2009
La-9	Rožhu Bog	1	Mire	Kušķe *et al.* 2011
La-10	Puikule Mire	1	Mire	Ratniece 2011
La-11	Zilais Mire	1	Mire	Kalniņa *et al.* 2008

Site Code	**Site Name**	14C dates ≤ 1500 14Cyrs BP	**Deposit type**	**References**
		LITHUANIA		
Li-1	Impiltis	3	Cultural layer/riverbed	Stančikaitė *et al.* 2009
Li-2	Lake Biržulis	1	Lake	Stančikaitė *et al.* 2006
Li-3	Kuršių Nerija	1	Buried soil	Moe *et al.* 2005
Li-4	Juodonys, Baltija Uplands	1	Mire	Stančikaitė *et al.* 2004
		POLAND		
P-1	Jelenia Wyspa Mire, Tuchola	2	Mire	Lamentowicz *et al.* 2007
P-2	Lake Miłkowski	1	Lake	Madeja *et al.* 2010; Wacnik *et al.* 2012
P-3	Napole	1	Mire	Filbrandt-Czaja, Noryśkiewicz 2003
P-4	Jezioro Klasztorne	1	Lake	Filbrandt-Czaja and Noryśkiewicz 2003
P-5	Linje Mire	2	Mire	Noryśkiewicz 2005
P-6	Malbork I	1	Cultural layers	Brown, Pluskowski 2011
P-7	Malbork II	5	Mire	Brown, Pluskowski 2011
P-8	Stazki	9	Mire	Lamentowicz *et al.* 2008a
P-9	Kluki	3	Mire	Tobolski 1987
P-10	Słupiańska Bay (Wigry Lake) WZS03	2	Lake	Kupryjanowicz 2007; Pitrowska *et al.* 2007
P-11	Gizdepka	1	Puck Lagoon	Moitk-Szpiganowicz *et al.* 2010
P-12	Beka	2	Puck lagoon	Moitk-Szpiganowicz *et al.* 2010
P-13	Stagna	3	Vistula Delta lagoon shore	Moitk-Szpiganowicz *et al.* 2010
P-14	Gołębiewo II	3	Mire	Latałowa *et al.* 2009
P-15	Chełmno	3	Floodplain	Noryśkiewicz 2004a
P-16	Uść	5	Mire	Noryśkiewicz 2004b
P-17	Tuchola peatland	1	Mire	Lamentowicz *et al.* 2008b
P-18	Darzlubi Forest	1	Mire	Latałowa 1982
P-19	Czystochleb	1	Mire	Filbrandt-Czaja and Noryśkiewicz 2003
P-20	Lake Woryty WOR80N	1	Lake	Pawlikowski *et al* 1982
P-21	Lake Zawada	1	Lake	Noryśkiewicz 2004
P-22	Radzyń Chełminski	3	Lake	Wynne 2011
P-23	Lake Wielkie Gacno	2	Lake	Hjelmroos 1981
P-24	Wierzchlas Site		Lake	Pidek et al. 2009
P-25	Lake Ostrowite	1	Lake	Milecka, Szeroczyńska 2005
P-26	Lake Wojnowo	2	Lake	Wacnik 2009; Wacnik *et al.* 2012
P-27	Vilikoye Bog	8	Mire	Arslanov *et al.* 2011

VIDURAMŽIŲ KRAŠTOVAIZDŽIO TRANSFORMACIJA PIETRYČIŲ IR PIETŲ PABALTIJYJE: PALEOAPLINKOS PERSPEKTYVOS KOLONIZUOJANT KAIMYNINIUS KRAŠTOVAIZDŽIUS

ALEX BROWN,
ALEKSANDER PLUSKOWSKI

Santrauka

Baltijos regiono viduramžių istorijoje dominuoja XIII–XV amžiais vykusi christianizacija. Kryžiuočiai turėjo ženklią įtaką kraštovaizdžio struktūros, nuosavybės ir administravimo pokyčiams kartu su reikšmingais žemėnaudos pakitimais. Vis dėlto mūsų supratimas apie kryžiuočių poveikį aplinkai yra pagrįstas beveik išimtinai rašytiniais šaltiniais. Šioje publikacijoje, akcentuojant ekologinę christianizacijos įtaką, apibendrinami egzistuojantys palinologiniai duomenys apie viduramžių kraštovaizdžio transformacijas Pietryčių bei Rytų Baltijos regione ir apžvelgiami keli esminiai klausimai, iššūkiai bei perspektyvos ateities tyrimams.

Vertė Miglė Stančikaitė