NORTHERN EMPORIUM

Vol. 1 The making of Viking-age Ribe

Edited by Søren M. Sindbæk

Northern Emporium

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A glimpse into structures from the eighth century

Aoife Daly

Background

Dendrochronological studies are a vital source for the history of Ribe's emporium. The early levels of the site's stratigraphy have favourable preservation of organic materials, and tree-ring dates have previously been important in framing earlier work on the chronology of the settlement. This is a statement with considerable caveats, however. Only very few dates are available to qualify the date previously established for the probable foundation of the emporium in 'c. 705-710' (Christensen 1990). Younger strata at the site are highly oxidized, and while a full 47 wood samples could be dated from the best-studied excavation, ASR 9 Posthuset, the latest precise date obtained among these was around 741 (Feveile & Jensen 2006, 126).

For the present study, remains of oak structures found during the excavations at SJM 3 Posthustorvet in Ribe were sampled for dendrochronology. These samples are taken from each timber by sawing a slice through the wood. The analysis entails gaining a clear view of the cross-section of the wood to enable accurate and uninterrupted measurement of every tree-ring through the tree's growth. By comparing the resulting series of measurements from each timber with each other and with tree-ring datasets from a range of other sites, it has been possible to establish the chronological framework for the recorded building activity at the site in the early and mid-eighth century. It also allows us to establish where the trees used for structures on the site might have grown, and to examine aspects of the wood resource usage in Ribe's early urban environment.

Method

Trees growing in temperate climates form annual growth rings, and their ring widths vary according to precipitation and temperature. Dendrochronology is a precise dating technique that utilizes this natural phenomenon by measuring the rings throughout the wood and comparing the pattern of wide and narrow rings between many different timber samples. (For an in-depth description of the method, see e.g. Baillie 1982; Hillam 1998.) Trees of the same species growing in one region will exhibit a similar pattern of wide and narrow rings as they are exposed to the same climate. Therefore, measurements of the growth rings can be cross-matched with other tree-ring datasets in order to date the wood sample. If the bark, or bark edge, is preserved on a sample, then the exact felling year can be identified. As timber that people use for buildings and artefacts is invariably trimmed or modified when incorporated into a structure, often the bark and some of the outer rings have been removed. Therefore, in spite of the enormous accuracy of the dendrochronological technique, we often need to account for the missing rings when we wish to use the method to tell us about the chronology of past human activity – the act of felling a tree. Tree-ring series of more than approximately 80 continuous rings are usually required for successful dating. The dendrochronology technique also allows us to suggest the region where the tree grew, since the regional climate variation influences wood growth.

In the laboratory, the samples are rinsed and the cross-section of the wood is pared down with very sharp razor blades so that a clear view of the section all the way through the growth of the tree is revealed. If the sample is very soft and delicate, it can be frozen before paring, but this was not necessary for the samples from Ribe. Every tree ring that is preserved on the sample is measured, from the innermost to the outermost, at an accuracy of +/- 0.01 mm. The presence of sapwood and/or bark edge is also recorded. The measurements are made using a measuring stage, in this case developed by Ian Tyers (Sheffield) using a Heidenhain linear encoder; the analysis utilized Tyers' software DENDRO (Tyers 1997). For calculating the correlation between all the tree-ring series produced, Student's *t*-test (Student 1908), adapted for dendrochronology (Baillie & Pilcher 1973), is used to identify cross-matching positions. These correlation positions are also evaluated through visual examination of plots of the tree-ring curves.

Results

Every piece of wood found during the excavation was initially screened by archaeobotanist Peter Hambro Mikkelsen (Moesgaard Museum) to determine which samples were suitable for dating. Overall, 86 samples were selected for dendrochronological examination. All are of oak (*Quercus sp.*). Nineteen of the oak samples were found to contain far too few rings (fewer than 40) to justify analysis. Thus, all oak samples containing more than 40 tree rings – a total of 67 – were measured and included in this analysis; of these, 48 could be successfully

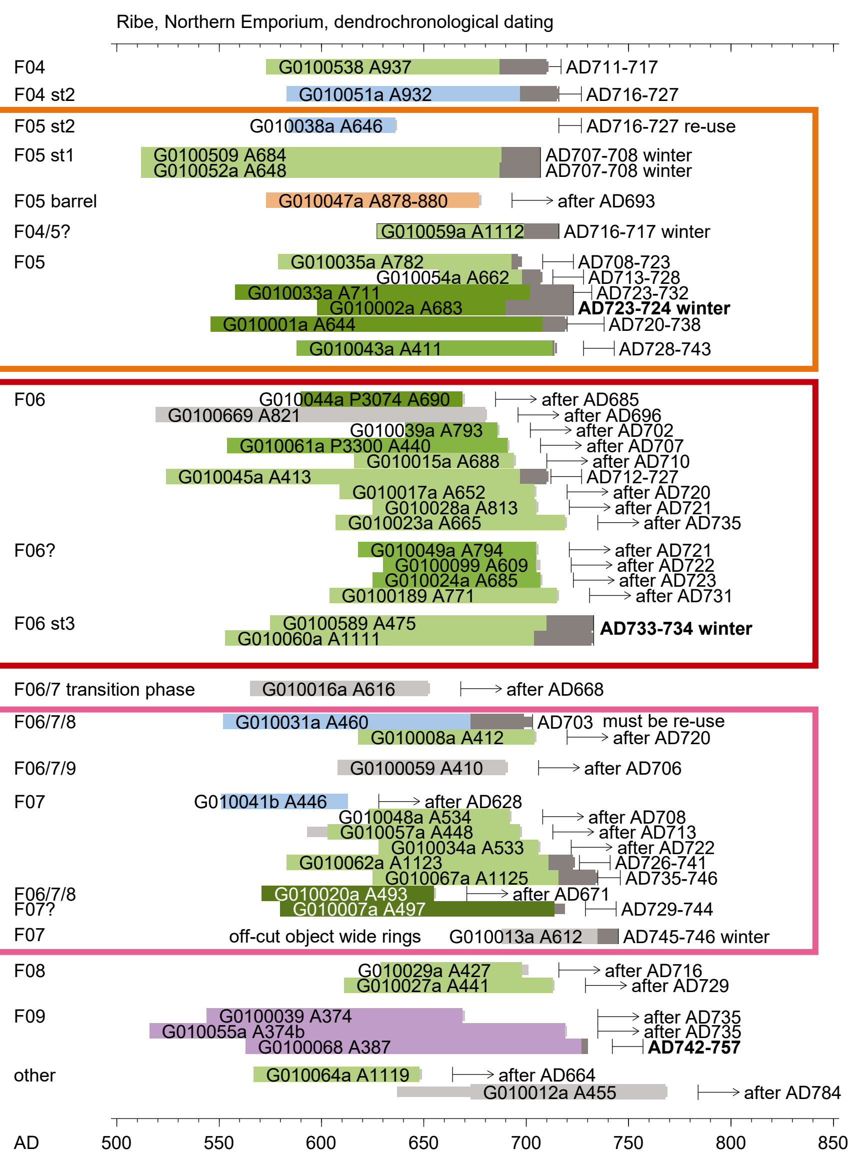

Figure 9.1. *Bar diagram of the chronological position of all dated samples. The bars represent the chronological position of each sample. The dark grey ends represent the sapwood. The line symbols represent the probable date for the felling of each tree. Illustration: Aoife Daly.*

dated. The analysis was carried out without knowledge of the stratigraphic or contextual details of the timbers sampled, and all dating positions were therefore identified wholly independently of the archaeological context. For example, in two instances the dendrochronological analysis suggested that two separate samples come from a single tree. Subsequent examination of the context of these examples confirmed that these two samples were in fact taken from the same timber at separate phases of the excavation.

The correlation between the tree-ring curve from each dated sample and all other samples at their dated position is presented in Table 9.1. It utilizes the *t*-value (a correlation statistic) as a measure of similarity between each sample. It is then sorted according to the samples that display the highest correlation. The values are shaded with grey to highlight the high *t*-values. As indicated, some pairs of samples agree so well that I have suggested they come from the same tree. This is the case for samples A646 and A932 ('same tree 2') and for samples A475 and A1111 ('same tree 3'). As mentioned above, there are also some duplicate samples from the same timber; the two samples designated 'same tree 1', as identified in the dendrochronological analysis, are from a single timber. Other duplicates, from timber A374 (A374 and A374b) were intentional, as it was suspected that more sapwood might be preserved on the second sample. The dendrochronological analysis did not specifically identify these as possibly coming from the same tree, but the correlations between these two are quite high ($t = 6.53$) and the similarity of their tree-ring curves, when compared visually, does not exclude the possibility that these are indeed from a single tree. In the analysis, I placed these two in group 2, as these correlate well with one more sample (highlighted in purple in Table 9.1 and in Fig. 9.1).

This correlation matrix enables us to try to identify groups of timbers from the site in order to aid assessments of whether the data indicates discrete groups of material. Particularly where many samples did not have bark or even the outer sapwood preserved, this strategy could allow allocation of homogeneous groups of timber that might come from the same woodland and, by extension, could belong to a single felling event. The material from Ribe displays a very broad intercorrelation, which allowed the definition of one large group (group 1, highlighted in green in Table 9.1 and Fig. 9.1) and two smaller groups (purple and blue). Within the green group, a number of sub-groups were also suggested; these are highlighted in various shades of green in the graphs. When we compared these groupings with the stratigraphical and contextual details at the site, they contributed to confirming the chronological context for many of the structures.

Even though some small groups could be suggested, there is no perfectly clear separation of the material in the assemblage of dated timbers. Correlation with other datasets in Northern Europe (discussed in more detail below) demonstrates that the material was found generally in the hinterland of the town. The exception is a single barrel stave, which is also discussed below.

The details of the dating of each sample are illustrated in Fig. 9.1. Each bar represents the chronological position of the preserved tree-rings in each sample. If sapwood was preserved, it is shown with dark grey shading. Otherwise, the bars are coloured green, blue, or purple according to the groups suggested in the analysis visualized in Table 9.1 (the light grey bars were not assigned to any of the groups, while the barrel stave is highlighted in orange). If bark is preserved, not only can the felling date for the tree be determined, but also the season. As can be seen, all samples with the bark edge preserved were felled in the trees' dormant season (c. October to April). Where bark is not preserved but sapwood is present, the felling of the tree is estimated. For all the dated structural timber from this analysis, an estimate for Northern Germany is used. Here, oak trees that grow to be around 100 years old have, on average, 20 (-5+10) rings of sapwood (Hollstein 1980). Samples with only heartwood preserved provide a *terminus post quem*.

After the dendrochronological analysis was complete, these results were juxtaposed with the stratigraphic framework for the site. Therefore, the diagram (Fig. 9.1) and the chronology of the site are depicted according to the groupings illustrated. The dating results presented consider the dendrochronological evidence alone, and reference is not made to the dating of associated contexts from the site by other means.

Phases F4 and F5

Only two of the dendrochronologically dated samples are placed with certainty in the earliest stratigraphically identified phase where timber is preserved (F4). The first timber (A932), a horizontal timber discarded in the upper part of the infill of a sunken-featured building

				G0100059	G010012a	G010013a	G010017a	G010023a	G010028a	G010015a	G0100099	G010024a	G010039a	G010061a	G010049a	G010043a	G010057a	G0100538	G010048a	G010045a	G010034a	G010001a	G010033a
		A410	G0100059	*	\	\	1.82	1.55	1.79	2.79	2.7	3.48	1.89	3.37	2.19	2.17	3.25	1.47	2.76	2.11	1.86	1.73	1.11
		A455	G010012a	\	*	4.24	2.54	1.66	1.62	\	1.27	1.48	\	\	2.06	0.05	\	0.56	\	4.48	1.54	1.43	2.06
		A612	G010013a	\	4.24	*	\	1.96	\	\	\	\	\	\	\	\	\	\	\	\	\	3.98	4.57
Group 1 G010M001	1	A652	G010017a	1.82	2.54	\	*	5.51	4	2.34	2.84	1.23	0.86	1.89	1.61	2.19	2.15	1.63	1.17	3.64	2.26	4.39	3.1
	1	A665	G010023a	1.55	1.66	1.96	5.51	*	2.98	4.6	4.36	3.25	3.73	3.06	2.84	5.23	2.66	3.57	2.66	3.33	4.79	2.26	2.83
	1	A813	G010028a	1.79	1.62	\	4	2.98	*	4.08	4.89	4.77	5.14	3.92	4	4.88	5.67	3.26	5.14	1.95	3.29	3.84	2.32
	1	A688	G010015a	2.79	\	\	2.34	4.6	4.08	*	3.92	4.86	4.58	3.83	3.8	5.79	3.64	2.53	4.72	2.05	4.99	3.31	2.02
	1a	A609	G0100099	2.7	1.27	\	2.84	4.36	4.89	3.92	*	5.37	7.02	4.86	6.57	6.3	3.14	4.79	4.39	3.83	2.97	3.17	2.08
	1a	A685	G010024a	3.48	1.48	\	1.23	3.25	4.77	4.86	5.37	*	9.54	5.15	4.71	7.03	5.46	3.61	5.93	4.27	4.7	2.94	1.92
	1a	A793	G010039a	1.89	\	\	0.86	3.73	5.14	4.58	7.02	9.54	*	8.45	7.38	6.77	6.28	4.23	5.32	3.46	4.02	2.84	1.84
	1a	A440	G010061a	3.37	\	\	1.89	3.06	3.92	3.83	4.86	5.15	8.45	*	2.46	3.06	4.17	5.54	4.46	3.07	2.68	4.19	2.89
	1a	A794	G010049a	2.19	2.06	\	1.61	2.84	4	3.8	6.57	4.71	7.38	2.46	*	3.83	4.75	3.1	3.42	4.41	3.53	2.88	2.85
	1a	A411	G010043a	2.17	0.05	\	2.19	5.23	4.88	5.79	6.3	7.03	6.77	3.06	3.83	*	3.39	3.74	4.01	2.82	3.05	3.02	2.81
	1	A448	G010057a	3.25	\	\	2.15	2.66	5.67	3.64	3.14	5.46	6.28	4.17	4.75	3.39	*	3.74	4.22	4.6	3.59	4.2	3.22
	1	A937	G0100538	1.47	0.56	\	1.63	3.57	3.26	2.53	4.79	3.61	4.23	5.54	3.1	3.74	3.74	*	2.41	3.68	1.64	2.1	3.78
	1	A534	G010048a	2.76	\	\	1.17	2.66	5.14	4.72	4.39	5.93	5.32	4.46	3.42	4.01	4.22	2.41	*	2.89	3.8	2.62	1.61
	1	A413	G010045a	2.11	4.48	\	3.64	3.33	1.95	2.05	3.83	4.27	3.46	3.07	4.41	2.82	4.6	3.68	2.89	*	5.58	4.88	4.51
	1	A533	G010034a	1.86	1.54	\	2.26	4.79	3.29	4.99	2.97	4.7	4.02	2.68	3.53	3.05	3.59	1.64	3.8	5.58	*	4.82	4.04
	1b	A644	G010001a	1.73	1.43	3.98	4.39	2.26	3.84	3.31	3.17	2.94	2.84	4.19	2.88	3.02	4.2	2.1	2.62	4.88	4.82	*	11.1
	1b	A711	G010033a	1.11	2.06	4.57	3.1	2.83	2.32	2.02	2.08	1.92	1.84	2.89	2.85	2.81	3.22	3.78	1.61	4.51	4.04	11.1	*
	1b	A690	G010044a	3.26	\	\	3.83	3.56	1.5	3.41	2.47	4.89	\	5.37	3.14	1.02	3.16	2.47	1.8	3.32	5.98	5.75	5.01
	1b	A683	G010002a	2.25	0.33	0.68	2.85	2.53	1.64	1.42	0.76	1.75	1.95	4.82	1.78	1.64	3.69	2.79	1.2	2.64	2.65	5.8	8.13
	1	A1112	G010059a	2.16	1.22	\	2.94	4.97	2.22	3.76	3.93	4.87	3.76	3.94	2.91	4.25	2.03	4.49	2.11	3.03	5.16	3.25	3.72
	same tree 3	A475	G0100589	0.26	2.16	1.37	3.27	2.12	0.62	-	1.53	-	-	0.44	0.61	1.82	-	1.19	1.32	1.95	2.01	3.1	5.17
		A1111	G010060a	0.6	1.52	0.31	2.01	1.09	0.4	0.59	0.83	-	-	1.73	0.27	1.87	1	0.87	1.06	2.56	2.69	4.42	4.06
	1	A1123	G010062a	2.24	1.98	0.93	1.37	0.53	1.84	1.25	1.78	2.33	2.11	3.69	1.44	2.27	3.1	1.7	2.8	1.82	2.16	4.45	4.93
	1	A427	G010029a	2.22	\	\	0.86	2.16	2.07	2.2	2.14	2.71	1.65	1.76	2.24	2.93	2.93	1.57	1.95	2.15	3.36	5.36	4.62
	1	A412	G010008a	2.73	1.61	\	2.94	1.67	1.09	3.27	2.1	1.79	2.17	2.9	1.64	2.72	1.57	1.19	1.02	2.84	3.37	4.14	3.3
	1	A1119	G010064a	0.28	\	\	1.34	1.87	\	1.35	\	\	\	2.82	1.51	0.77	1.1	1.32	\	1.46	\	5.27	4.25
	same tree 1	A684	G0100509	0.37	1.85	\	1.29	1.7	2.42	1.35	2.44	1.49	2.76	2.2	3	0.67	2.15	2.14	1.22	1.48	3.13	4.93	5.86
		A648	G010052a	-	2.59	\	0.01	0.79	2.02	1.58	1.6	0.76	1.42	1.75	2.44	0.7	1.27	1.84	0.94	0.67	2.42	4.17	4.69
	1	A782	G010035a	2.08	\	\	2.38	2.36	1.03	1.73	2.53	1.62	1.07	3.56	3.7	1.2	1.18	2.07	1.01	1.47	2.16	4.18	4.05
	1	A771	G0100189	1.9	1.13	\	-	0.48	2	2.93	1.92	2.28	2.97	5.26	3.03	3.77	3.34	4.31	1.22	1.62	1.92	3.27	3.67
	1	A441	G010027a	3.2	1.02	\	0.27	1.87	1.76	1.96	1.93	3.79	2.55	2.19	3.9	2.26	3.15	2.78	3.45	2.16	3.31	2.18	3.9
	1c	A497	G010007a	2.71	0.52	\	-	0.37	1.01	-	-	0.49	-	2.58	1.8	0.72	1.5	2.15	0.76	0.18	-	4.68	4.96
	1c	A493	G010020a	2.25	\	\	0.04	1.01	1.93	0.92	\	1.36	\	5.85	2.68	-	0.21	3.02	2.73	1.27	\	3.35	1.69
		A1125	G010067a	3.26	4.03	4.99	3.28	3.93	3.67	3.39	3.37	3.16	3.06	2.73	3.94	4.52	3.12	3.71	2.13	3.19	2.26	4.71	4.86
		A662	G010054a	0.39	3.49	\	3.08	4.41	1.09	2.87	2.38	0.02	1.63	1.47	1.82	2.05	0.6	2.64	0.74	4.31	3.79	4.27	3.44
Group 3 G010M003	3	A460	G010031a	-	\	\	1.57	2.11	0.49	2	0.23	0.63	0.44	3.49	0.44	0.67	0.25	1.65	-	1.19	2.09	2.29	1.58
	same tree 2	A646	G010038a	\	\	\	\	1.4	\	\	\	\	\	5.05	\	0.92	0.37	3.93	\	2.09	\	2.8	2.52
		A932	G010051a	1.46	-	\	2.52	2.44	0.18	2.03	1.68	2.04	1.86	5.63	0.03	1.32	1.88	3.83	2.17	2.14	1.04	3.01	2.97
	3	A446	G010041b	\	\	\	\	\	\	\	\	\	\	7.97	\	\	\	3.45	\	3.81	\	2.98	2.56
Group 2 G010M002	2	A374b	G010055a	1.56	0.51	1.94	0.92	3.19	3.37	1.61	2.05	1.26	0.4	2.63	1.88	1.84	2.41	2.15	2.96	5.13	0.55	3.84	1.78
	2	A387	G0100068	3.75	1.46	3.02	2.32	2.64	3.43	4.75	2.15	2.54	1.65	4.58	2.28	2.4	4.67	2.43	3.25	2.19	0.89	4.68	4.17
	2	A374	G0100039	1.04	\	\	-	1.76	0.88	2	0.78	0.56	\	4.51	1.23	1.57	3.21	0.95	1.37	2.64	1.61	2.61	1.9
		A821	G0100669	-	\	\	2.28	0.06	1.04	2.22	1.87	0.45	1.68	2.71	1.14	1.14	2.03	0.21	1.57	1.6	1.14	3.86	3.56
		A616	G010016a	1	\	\	2.14	2.24	\	3.62	\	\	\	2.81	2.73	1.33	1.4	1.31	1.99	0.27	\	3.38	3.54
	barrel	A878-880	G010047a	-	\	\	-	-	0.94	-	0.03	0.18	0.83	1.15	-	0.28	1.9	0.42	0.38	0.51	-	0.8	-

Table 9.1. *Matrix of correlation between all dated samples.*

G010044a	G010002a	G010059a	G0100589	G010060a	G010062a	G010029a	G010008a	G010064a	G0100509	G010052a	G010035a	G0100189	G010027a	G010007a	G010020a	G010067a	G010054a	G010031a	G010038a	G010051a	G010041b	G010055a	G010068	G010039	G0100669	G010016a	G010047a
3.26	2.25	2.16	0.26	0.6	2.24	2.22	2.73	0.28	0.37	-	2.08	1.9	3.2	2.71	2.25	3.26	0.39	-	\	1.46	\	1.56	3.75	1.04	-	1	-
\	0.33	1.22	2.16	1.52	1.98	\	1.61	\	1.85	2.59	\	1.13	1.02	0.52	\	4.03	3.49	\	\	-	\	0.51	1.46	\	\	\	\
\	0.68	\	1.37	0.31	0.93	\	\	\	\	\	\	\	\	\	\	4.99	\	\	\	\	\	1.94	3.02	\	\	\	\
3.83	2.85	2.94	3.27	2.01	1.37	0.86	2.94	1.34	1.29	0.01	2.38	-	0.27	-	0.04	3.28	3.08	1.57	\	2.52	\	0.92	2.32	-	2.28	2.14	-
3.56	2.53	4.97	2.12	1.09	0.53	2.16	1.67	1.87	1.7	0.79	2.36	0.48	1.87	0.37	1.01	3.93	4.41	2.11	1.4	2.44	\	3.19	2.64	1.76	0.06	2.24	-
1.5	1.64	2.22	0.62	0.4	1.84	2.07	1.09	\	2.42	2.02	1.03	2	1.76	1.01	1.93	3.67	1.09	0.49	\	0.18	\	3.37	3.43	0.88	1.04	\	0.94
3.41	1.42	3.76	-	0.59	1.25	2.2	3.27	1.35	1.35	1.58	1.73	2.93	1.96	-	0.92	3.39	2.87	2	\	2.03	\	1.61	4.75	2	2.22	3.62	-
2.47	0.76	3.93	1.53	0.83	1.78	2.14	2.1	\	2.44	1.6	2.53	1.92	1.93	-	\	3.37	2.38	0.23	\	1.68	\	2.05	2.15	0.78	1.87	\	0.03
4.89	1.75	4.87	-	-	2.33	2.71	1.79	\	1.49	0.76	1.62	2.28	3.79	0.49	1.36	3.16	0.02	0.63	\	2.04	\	1.26	2.54	0.56	0.45	\	0.18
\	1.95	3.76	-	-	2.11	1.65	2.17	\	2.76	1.42	1.07	2.97	2.55	-	\	3.06	1.63	0.44	\	1.86	\	0.4	1.65	\	1.68	\	0.83
5.37	4.82	3.94	0.44	1.73	3.69	1.76	2.9	2.82	2.2	1.75	3.56	5.26	2.19	2.58	5.85	2.73	1.47	3.49	5.05	5.63	7.97	2.63	4.58	4.51	2.71	2.81	1.15
3.14	1.78	2.91	0.61	0.27	1.44	2.24	1.64	1.51	3	2.44	3.7	3.03	3.9	1.8	2.68	3.94	1.82	0.44	\	0.03	\	1.88	2.28	1.23	1.14	2.73	-
1.02	1.64	4.25	1.82	1.87	2.27	2.93	2.72	0.77	0.67	0.7	1.2	3.77	2.26	0.72	-	4.52	2.05	0.67	0.92	1.32	\	1.84	2.4	1.57	1.14	1.33	0.28
3.16	3.69	2.03	-	1	3.1	2.93	1.57	1.1	2.15	1.27	1.18	3.34	3.15	1.5	0.21	3.12	0.6	0.25	0.37	1.88	\	2.41	4.67	3.21	2.03	1.4	1.9
2.47	2.79	4.49	1.19	0.87	1.7	1.57	1.19	1.32	2.14	1.84	2.07	4.31	2.78	2.15	3.02	3.71	2.64	1.65	3.93	3.83	3.45	2.15	2.43	0.95	0.21	1.31	0.42
1.8	1.2	2.11	1.32	1.06	2.8	1.95	1.02	\	1.22	0.94	1.01	1.22	3.45	0.76	2.73	2.13	0.74	-	\	2.17	\	2.96	3.25	1.37	1.57	1.99	0.38
3.32	2.64	3.03	1.95	2.56	1.82	2.15	2.84	1.46	1.48	0.67	1.47	1.62	2.16	0.18	1.27	3.19	4.31	1.19	2.09	2.14	3.81	5.13	2.19	2.64	1.6	0.27	0.51
5.98	2.65	5.16	2.01	2.69	2.16	3.36	3.37	\	3.13	2.42	2.16	1.92	3.31	-	\	2.26	3.79	2.09	\	1.04	\	0.55	0.89	1.61	1.14	\	-
5.75	5.8	3.25	3.1	4.42	4.45	5.36	4.14	5.27	4.93	4.17	4.18	3.27	2.18	4.68	3.35	4.71	4.27	2.29	2.8	3.01	2.98	3.84	4.68	2.61	3.86	3.38	0.8
5.01	8.13	3.72	5.17	4.06	4.93	4.62	3.3	4.25	5.86	4.69	4.05	3.67	3.9	4.96	1.69	4.86	3.44	1.58	2.52	2.97	2.56	1.78	4.17	1.9	3.56	3.54	-
*	6.25	7.41	1.76	2.24	4.54	3.07	4.19	3.63	1.51	0.58	3.48	3.23	4.88	3.94	4.8	2.26	\	3.46	4.08	4.2	\	-	1.14	0.93	1.94	3.16	-
6.25	*	4.06	3.06	4.32	4.77	3.69	4.11	3.34	1.56	1.4	4.61	4.51	3.05	5.04	2.75	2.98	1.68	1.79	4.02	3.8	\	-	1.8	1.79	1.79	3.64	-
7.41	4.06	*	2.17	1.74	1.85	3.73	4.03	\	1.52	1.36	2.49	1.96	3.32	0.33	\	3.57	3.46	2.38	\	2.41	\	-	0.61	0.2	1.32	\	-
1.76	3.06	2.17	*	12.4	4.79	2.55	3.14	2.21	0.85	-	3.88	0.94	0.82	1.52	1.92	2.31	3.66	1.27	1.05	2.65	-	-	-	-	-	0.99	-
2.24	4.32	1.74	12.4	*	4.03	2.44	4.25	2.14	0.86	0.14	2.82	2.39	0.08	1.32	1.67	2.18	4.71	0.9	0.56	2.42	1.91	0.81	0.11	2.53	1.67	1.48	0.34
4.54	4.77	1.85	4.79	4.03	*	4.14	4.11	1.58	1.64	1.96	4.97	3.12	2.53	4.19	4.97	1.45	2.24	0.19	2.59	3.51	1.44	0.79	0.63	1.06	1.57	1.86	-
3.07	3.69	3.73	2.55	2.44	4.14	*	2.95	\	0.44	0.92	3.27	2.61	3.34	2.4	\	4.89	1.84	-	\	1.71	\	0.08	0.61	1.52	-	\	1.05
4.19	4.11	4.03	3.14	4.25	4.11	2.95	*	1.09	0.94	0.46	3.12	3.84	0.6	0.49	1.39	3.72	3.95	1.09	\	2.9	\	-	-	-	2.77	2.85	0.49
3.63	3.34	\	2.21	2.14	1.58	\	1.09	*	1.57	2.2	2.6	1.57	2.38	2.42	3.49	\	\	1.03	2.07	2.86	1.54	0.83	2.82	1.56	2.46	3.28	-
1.51	1.56	1.52	0.85	0.86	1.64	0.44	0.94	1.57	*	21	1.85	1.88	2.99	1.28	0.39	2.74	2.55	2.13	1.29	0.11	0.92	0.47	3.03	0.87	2.62	0.92	1.14
0.58	1.4	1.36	-	0.14	1.96	0.92	0.46	2.2	21	*	1.53	1.99	3.14	1.95	1.67	2.14	2.19	1.74	1.17	-	0.82	1.86	3.03	1.11	1.94	2.53	0.42
3.48	4.61	2.49	3.88	2.82	4.97	3.27	3.12	2.6	1.85	1.53	*	2.95	2.2	3.23	3.28	5.07	3.29	2.13	3.61	4.37	2.07	0.38	1.59	0.15	1.65	1.99	-
3.23	4.51	1.96	0.94	2.39	3.12	2.61	3.84	1.57	1.88	1.99	2.95	*	2.6	2.58	2.42	4.42	2.36	1.53	0.05	-	\	0.42	0.64	2.34	1.02	1.9	0.56
4.88	3.05	3.32	0.82	0.08	2.53	3.34	0.6	2.38	2.99	3.14	2.2	2.6	*	2.78	3.26	3.32	-	-	\	-	\	0.52	1.93	2.76	-	1.72	-
3.94	5.04	0.33	1.52	1.32	4.19	2.4	0.49	2.42	1.28	1.95	3.23	2.58	2.78	*	9.13	2.12	0.11	1.37	2.08	2.02	3.38	2.77	2.73	2.47	0.69	2.9	-
4.8	2.75	\	1.92	1.67	4.97	\	1.39	3.49	0.39	1.67	3.28	2.42	3.26	9.13	*	2.05	\	2.64	3.33	4.09	4.09	2.77	2.44	1.96	1.91	2.89	-
2.26	2.98	3.57	2.31	2.18	1.45	4.89	3.72	\	2.74	2.14	5.07	4.42	3.32	2.12	2.05	*	5.24	0.75	\	2.45	\	2.05	3.28	0.01	0.12	\	0.53
\	1.68	3.46	3.66	4.71	2.24	1.84	3.95	\	2.55	2.19	3.29	2.36	-	0.11	\	5.24	*	1.29	\	1.42	\	1.58	1.83	\	\	\	\
3.46	1.79	2.38	1.27	0.9	0.19	-	1.09	1.03	2.13	1.74	2.13	1.53	-	1.37	2.64	0.75	1.29	*	4.97	3.25	2.7	0.18	1.17	0.34	1.67	1.31	0.99
4.08	4.02	\	1.05	0.56	2.59	\	\	2.07	1.29	1.17	3.61	0.05	\	2.08	3.33	\	\	4.97	*	10.3	4.12	-	1.07	0.48	2.34	1.48	0.16
4.2	3.8	2.41	2.65	2.42	3.51	1.71	2.9	2.86	0.11	-	4.37	-	-	2.02	4.09	2.45	1.42	3.25	10.3	*	4.06	1.17	2.72	1.31	2.51	2.23	0.35
\	\	\	-	1.91	1.44	\	\	1.54	0.92	0.82	2.07	\	\	3.38	4.09	\	\	2.7	4.12	4.06	*	2.86	2.26	3.47	4.11	1.3	0.49
-	-	-	-	0.81	0.79	0.08	-	0.83	0.47	1.86	0.38	0.42	0.52	2.77	2.77	2.05	1.58	0.18	-	1.17	2.86	*	8.38	6.53	1.76	0.66	1.47
1.14	1.8	0.61	-	0.11	0.63	0.61	-	2.82	3.03	3.03	1.59	0.64	1.93	2.73	2.44	3.28	1.83	1.17	1.07	2.72	2.26	8.38	*	8.72	2.92	2.08	1.19
0.93	1.79	0.2	-	2.53	1.06	1.52	-	1.56	0.87	1.11	0.15	2.34	2.76	2.47	1.96	0.01	\	0.34	0.48	1.31	3.47	6.53	8.72	*	3.03	0.83	1.87
1.94	1.79	1.32	-	1.67	1.57	-	2.77	2.46	2.62	1.94	1.65	1.02	-	0.69	1.91	0.12	\	1.67	2.34	2.51	4.11	1.76	2.92	3.03	*	1.23	1.78
3.16	3.64	\	0.99	1.48	1.86	\	2.85	3.28	0.92	2.53	1.99	1.9	1.72	2.9	2.89	\	\	1.31	1.48	2.23	1.3	0.66	2.08	0.83	1.23	*	-
-	-	-	-	0.34	-	1.05	0.49	-	1.14	0.42	-	0.56	-	-	-	0.53	\	0.99	0.16	0.35	0.49	1.47	1.19	1.87	1.78	-	*

(K9), has sapwood preserved but no bark edge (Fig. 9.5). Its outermost, partially preserved tree-ring was formed in AD 716. With 18 sapwood rings preserved, the felling date for the tree that this sample is from is estimated to be AD 716-727. The excavators noted that there was 'full sapwood' on the outer edge, but this could not be confirmed with absolute certainty on the sample. Timber A937, found discarded horizontally in the same fill of sunken-featured building K9 as A932, is also assigned to phase F4 and is from a tree felled AD 711-717. This could conceivably belong with the group felled in 716-717.

A single upright post (timber A684) provides us with the earliest precise dating for timber from SJM 3 Posthustorvet. Two samples from this timber had the full sapwood to bark edge preserved. This tree was felled in winter AD 707-708. Stratigraphically, however, this timber is assigned to building K12 in phase F5. This building was raised above the filled-in pit K9; A932 therefore gives a *terminus post quem* for the construction of K12. The only way around this is to assume that A684 is reused wood.

Another sample, A646, which is assigned to phase F5, displays a tree-ring pattern that is highly similar to A932 ('same tree 2'; both highlighted in blue in Fig. 9.1) – so similar that it strongly indicates that these two samples are in fact from the same tree. This sample has only heartwood preserved, and in fact, its outermost preserved tree ring was formed in AD 636, meaning that as many as 80 outer rings are missing from this piece. The timber is a vertical stake, triangular in section. It might represent reuse of a reworked timber from an earlier structure.

A third timber felled around the same time as 'same tree 2', A1112, has full sapwood to bark edge. It is from a tree felled in winter 716-717.

A later felling of trees within this stratigraphic phase is represented by three samples (A711, A644, and A683), one of which, A683, has the bark edge preserved. This felling can be placed in winter AD 723-724. These three vertical posts were all part of the wall structure of building K12 and date the construction of this building. The three earlier timbers A646, A684, and A1112 are all part of an external row of posts (from buttresses or a fence) along the wall of K12. Their contemporaneity with the building is identified by the fact that they show charring at the top from the fire event. The explanation must be that these outer timbers were reused from earlier structures when K12 was built. This may have been at the same time that A932 and A937 were deemed to be unusable and were thus discarded as infill under the floor of the building. Another sample from this row, A411, is from a tree that was felled AD 728-743. As the date indicates, it must relate to repair work a few years after the house was built.

Overall, the site's building activity in phases F4 and F5 is characterized by felling every six to eight years and by the reuse of wood from earlier structures. It is possible to envisage that earlier structures would be dismantled to make way for the next, and any sound timber could be trimmed of rot and incorporated into the new building. This, of course, means that it is tricky to identify which felling phase provides us with the dating for the activity in this phase. The main clue available to us is the firm stratigraphic placement of timbers A932 and A937 in phase F4. We can place the establishment of the phase F5 structures in winter AD 723-724, and any earlier felling events represented must be reused timbers. The two timbers among the materials deposited in the pit from sunken-featured building K9 were probably deposited shortly after this building was dismantled. Their date might thus relate to the construction of building K9 in phase F4. If the timber dates the construction of the building to c. 716, it would indicate that K9 had a use-life of up to eight years.

One barrel stave belongs stratigraphically to phase F5. It has only heartwood preserved and is from a tree felled after AD 693. It is the only oak piece from the site that has been dendrochronologically identified as non-local. This is discussed further below.

Phase F6

Of the 13 dated samples that are placed stratigraphically in phase F6, only 3 have sapwood preserved (Fig. 9.5). One, A413 from construction K15, is from a tree felled in the range AD 712-727. We can suggest that A413 might represent the reuse of a timber from an earlier structure. The last two, A475 and A1111, both from construction on K11 on plot 2, have such similar tree-ring curves that they could well have come from the same tree ('same tree 3'). There is bark edge on one of these, so we can state that this tree was felled in winter AD 733-734. Building K11 was stratigraphically younger than K15, but probably contemporary with its successor on plot 1, K16. All the other samples lack sapwood, and all but one have *terminus post quem* dates before 733-734, so we might place this phase's building activity at the dating provided by the samples with bark edge: winter AD 733-734, ten years after the buildings from phase F5. The sample G010023a A665 has an estimated *terminus post quem* after AD 735, but as the estimate of sapwood is a statistical calculation of how many sapwood rings a tree might have had, it is not impossible that this sample is from a tree with slightly fewer sapwood rings than the majority. This would allow for it to belong to the same felling phase: winter AD 733-734.

Transition phase F6-F7

In the stratigraphy, a single timber represents activity in the transition between the F6 and F7 phases on the site: A616. Unfortunately, this sample has only heartwood preserved, so it can only provide a *terminus post quem* felling: after AD 668.

Phase F7

Of the seven dated samples that are securely placed in phase F7, three have sapwood preserved, but only one of these also has bark edge. The two structural timbers with sapwood are from trees felled AD 726-741 (A1123) and AD 735-746 (A1125), both from structure K17. If these two are from the same felling activity, we might combine their felling estimates and date the structural activity of this phase to c. AD 735-741. The timber with bark edge (A612) is not a structural timber, but a horizontally placed trapezoidal board. It is from a tree felled in winter AD 745-746.

Other timbers whose stratigraphic relationships are not so secure can be placed within this group. Timber A460 has sapwood and is from a tree felled around or shortly after AD 703, which must therefore represent reuse from an earlier structure. This sample may presently be the earliest-dated wood from Ribe's emporium. However, the bark edge was not preserved and the sapwood rings were very narrow, so it proved impossible to gain reliable measurements of the outermost four rings. If we include the unmeasured rings, this sample contained 30 sapwood rings. The sapwood statistic that we use to estimate the felling date of the tree is based on a statistical probability that 95% of trees fall within the range (15 -5+10 sapwood rings). If this tree is a statistical outlier in terms of the number of sapwood rings, the sample could easily be from a tree felled as late as 707, especially considering that, when the rings are narrow, more sapwood rings can be present. Timber A497 (from K17 or K36?), felled AD 729-744, might also be placed in phase F7.

Phase F8

Just two dated timbers are from phase F8, A427 and A441 (K20), and both have only heartwood preserved. A felling after AD 729 gives a *terminus post quem* for this phase.

Phase F9

Two timbers (represented by three samples) are from this phase: samples A374, A374b, and A387. This last sample has sapwood preserved and is from a tree felled AD 742-757. The two timbers were found lying horizontally, parallel to one another, and are interpreted as floorboards in building K38. These three form the dendrochronological 'group 2'.

Other timbers

A small group of dated samples have not been assigned clear groupings. They are all without sapwood, so the dendrochronology does not assist in elucidating the precise chronology for the felling of these trees.

The wood source

As has been explained above, the vast majority of the dated timbers from the site appear to have been sourced from the Ribe hinterland. We can say this because the material displays the highest correlation with other oak datasets from the region, as presented in a map showing the correlation between the Ribe group 1 average (G010M001) at its dated position with master and site chronologies across Northern Europe (Fig. 9.2). The *t*-value is the correlation measure used here, and each circle represents the *t*-value achieved with each dataset – the larger the circle, the higher the *t*-value. (For a detailed explanation of the technique used here and the underlying tree-ring data, see Daly 2007). The highest *t*-value that the Ribe group 1 chronology achieves is t = 14.19, with a chronology from timbers from a causeway across a marshy terrain found and excavated at Nybro in West Jutland (Frandsen 1999; Frandsen & Ravn 1999;

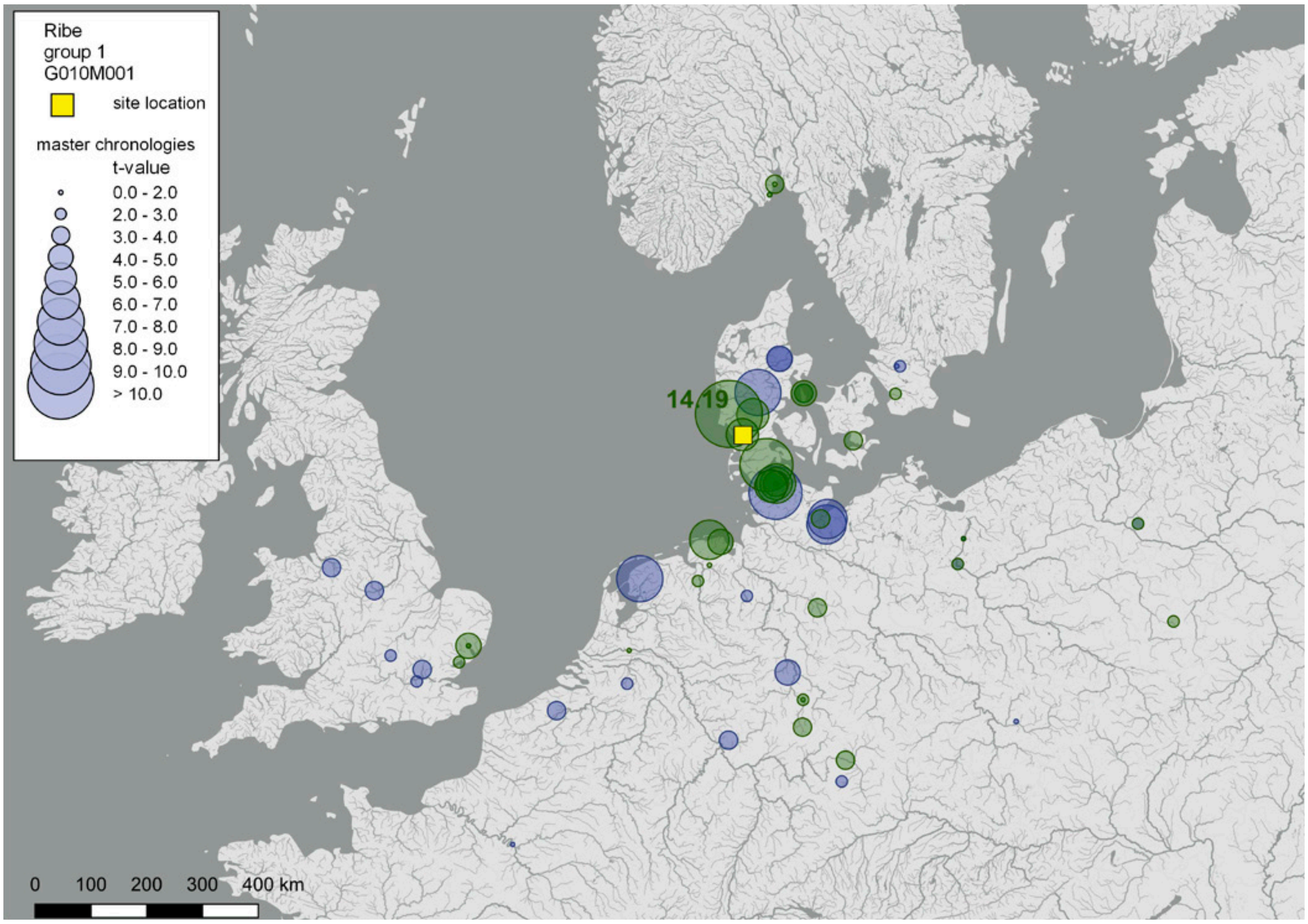

Figure 9.2. *Map showing the provenance of the main group of timbers from Ribe. The larger the dot, the higher the t-value. For details of the method, see e.g. Daly 2007. The river data is from Lehner & Grill 2013. Illustration: Aoife Daly.*

Ravn 1999). The dendrochronology of this timber causeway demonstrated that it had been built, repaired, and maintained for almost a century, from the 720s to 834 (Daly 1999; 2006). This site is just 50 km as the crow flies NNW of Ribe. The other Ribe groups display similar correlation distributions.

The barrel stave

Just one wooden piece from this analysis is set apart from this pattern. The dendrochronological dating of a barrel stave (as mentioned above) shows quite a different place of origin. However, we must first put this find into its wider context. Over many decades of excavation in Ribe, barrels were found that had been reused to line wells in the town. These barrels were analysed by diverse researchers (Carsten Sønderby, who was at the tree-ring laboratory at SKALK, and Kjeld Christensen, who was at the Danish National Museum). Using German chronologies, they independently found that these barrels dated to the eighth century. These scientists kindly shared the tree-ring data obtained from these barrels to enable us to examine the relationship between these barrels and yet another barrel found in 2000 during excavations in Ribe and subsequently analysed by the author (Daly 2000). These were found to display very high agreement with each other, and it was also confirmed that they were likely made from oak from the Rhine River hinterland (Daly 2007; 2011).

Oak barrels from the settlement at Dorestad in the Netherlands provide a parallel; they are of similar dating and are from a similar source (Eckstein et al. 1975). More recently, an extensive analysis of wood remains at the Rhine estuary came again into focus (Doeve 2015). Doeve demonstrated that this settlement at Oegstgeest-Rijnfront, Netherlands, dates to the seventh century AD. She also shows that barrels from three wells at the site are dendrochronologically very strongly related to these barrels in Ribe, and are, in fact, also related to two barrels

Filenames	-	-	G010047a A878-880	
-	start	dates	AD 573	
-	dates	end	AD 677	
Ribe 700s M1	AD 438	AD 700	9.86	Ribe 3 eighth-century barrels 10 timbers (Daly 2007)
ips683_t5	AD 506	AD 704	9.47	Ipswich 5 timbers (Tyers pers comm)
7035M001	AD 516	AD 694	8.88	Ribe Giørtzvej barrel in well A159 (Daly 2007)
T_DORE001	AD 458	AD 817	8.28	Dorestad (Rzepecki et al 2019)
T_MAIN012	AD 439	AD 716	8.24	Mainz Am Brand (Rzepecki et al 2019)
nlzuidmm	AD 427	AD 1752	8.08	South Netherlands (Jansma 1995)
T_ALTP001	AD 494	AD 691	6.93	Altrip (Rzepecki et al 2019)
T_TRIE091	AD 558	AD 719	6.84	Trier (Rzepecki et al 2019)
OEW_BA_QU_TG	AD 367	AD 638	6.58	Oegstgeest barrels western Netherlands (Doeve 2015)
DEholl80	400 BC	AD 1975	6.58	SW Germany (Hollstein 1980)
7005M00x	AD 449	AD 679	6.54	Ribe Dommerk.h. barrel 4 timbers (Daly 2007) (Nationalmuseet)
w466M01	AD 438	AD 700	6.36	Ribe Giørtzvej barrel 4 timbers (C. Sønderby, pers. comm.; Daly 2007)

Table 9.2. *Table showing the correlation (t-value) between the barrel stave from Ribe and a range of tree-ring datasets.*

from Ipswich in SE England (Doeve 2015, 87). The barrels from Oegstgeest-Rijnfront are earlier (outermost preserved ring with sapwood AD 638) than the Ribe and Ipswich examples, both of which date to around the turn of the seventh century.

Table 9.2 shows the highest *t*-values that the tree-ring curve from the single stave from Posthustorvet, Ribe, achieves when compared to Northern European tree-ring datasets. It clearly correlates with the Ipswich, Oegstgeest-Rijnfront, and eighth-century Ribe barrel datasets. The dating for the stave is a *terminus post quem* (after AD 693), but it belongs contextually in phase F5, which we have concluded was established around AD 723-724. This coincidence of oak wood for barrel manufacturing from a highly localized source, probably somewhere around the Lower Rhine, serves to demonstrate the connections by sea between the trading centres of Ribe and Ipswich to the Rhine estuary, thereby showing us where these networks gained access to the interior of the European continent.

The wood resource

The data from this study allows us a small insight into the usage and availability of oak for building in Ribe during the first half of the eighth century. As indicated, there appears to have been no need for import of timber from any substantial distance; local resources were exploited. Additionally, reuse of timber seems to have been a prevalent practice.

The rate of growth of the oak available for the settlers at Ribe, expressed as the average ring width of each sample, is stable throughout the decades for which we have dated material. Most of the trees grew in girth at a rate of 0.5 to 2 mm per year. The undated samples analysed display similar growth rates. There is just one exception to this – sample A612 – which grew faster, at 2.7 mm annually. We can use this as an indicator for how much the trees competed for nutrients and light, to try to gain some insight into how dense the tree cover was across the landscape. However, this is not a simple presumption to make. There could have been many other factors that affected how quickly trees grew on the western seaboard of Jutland, particularly if they were exposed to windy or salty conditions. Nevertheless, we can use this statistic to gain some insight into the timber used over time.

The graph in Fig. 9.3 presents the average growth rate of oaks found and analysed dendrochronologically in Denmark, dating to the last two millennia. This material has been presented previously (Daly 2017) but additional, subsequent datasets from ongoing analyses have been added. In this diagram, I distinguish between trees that, from the dendrochronological analysis, can be identified as being local (blue chevrons) and those that derive from imports (orange chevrons). The x-axis represents time, and each tree is placed according to its outermost measured tree-ring. The plot of average ring width of the dated trees from this study (SJM 3 Posthustorvet) is shown using green squares (except for the barrel stave, where red is used). It is clear that the material in Ribe is comparable to other Danish wood from the era, in that the bulk of samples display a very similar growth rate as wood from other sites.

In Fig. 9.4, we have focused on the time window between the seventh and mid-ninth centuries in order to compare the Ribe data with the material from the causeway at Nybro, the dataset with which the Ribe tree-

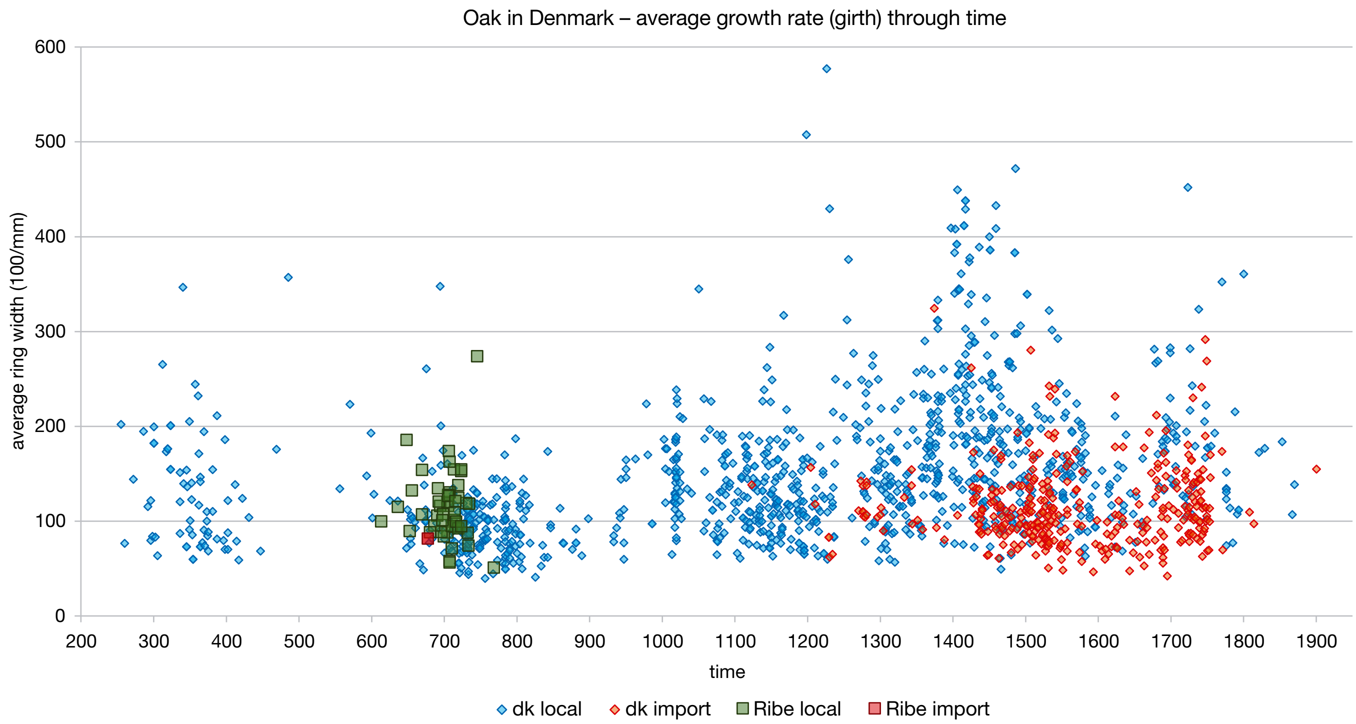

Figure 9.3. *Scattergram of average ring width per tree over time: local versus imported timber. Illustration: Aoife Daly.*

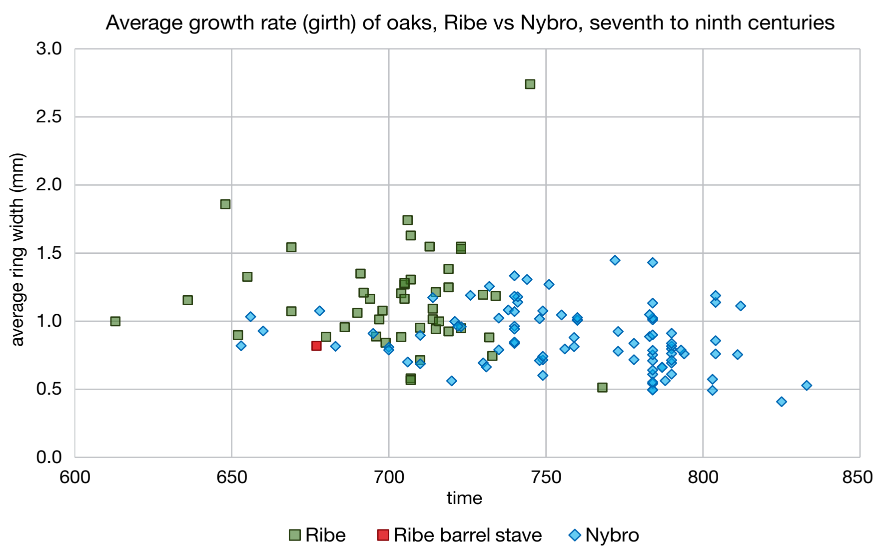

Figure 9.4. *Scattergram of average ring width per tree: comparison between Ribe and Nybro. Illustration: Aoife Daly.*

ring curves correlate best. It is notable, in this connection, that Nybro is situated just 50 km from Ribe. The trees from these two sites display very consistent growth rates throughout the period. If we were seeing an intensive exploitation of the forest/woodland from the building activity in this region, we might expect to see a tendency to faster-growing (generally wider-ringed) trees as the landscape became more open and trees were subject to less competition. But this seems not to be the case. Building activity in the region seems to have remained within a sustainable level, at least as far as availability of oaks is concerned, throughout the seventh and eighth centuries in this part of western Jutland. Incidentally, the samples from both Ribe and Nybro include trees whose *innermost* rings were formed in the first half of the sixth century. This adds to the impression that the exploitation of woodland in the area did not result in the removal of long-lived oaks, even well into the late eighth century.

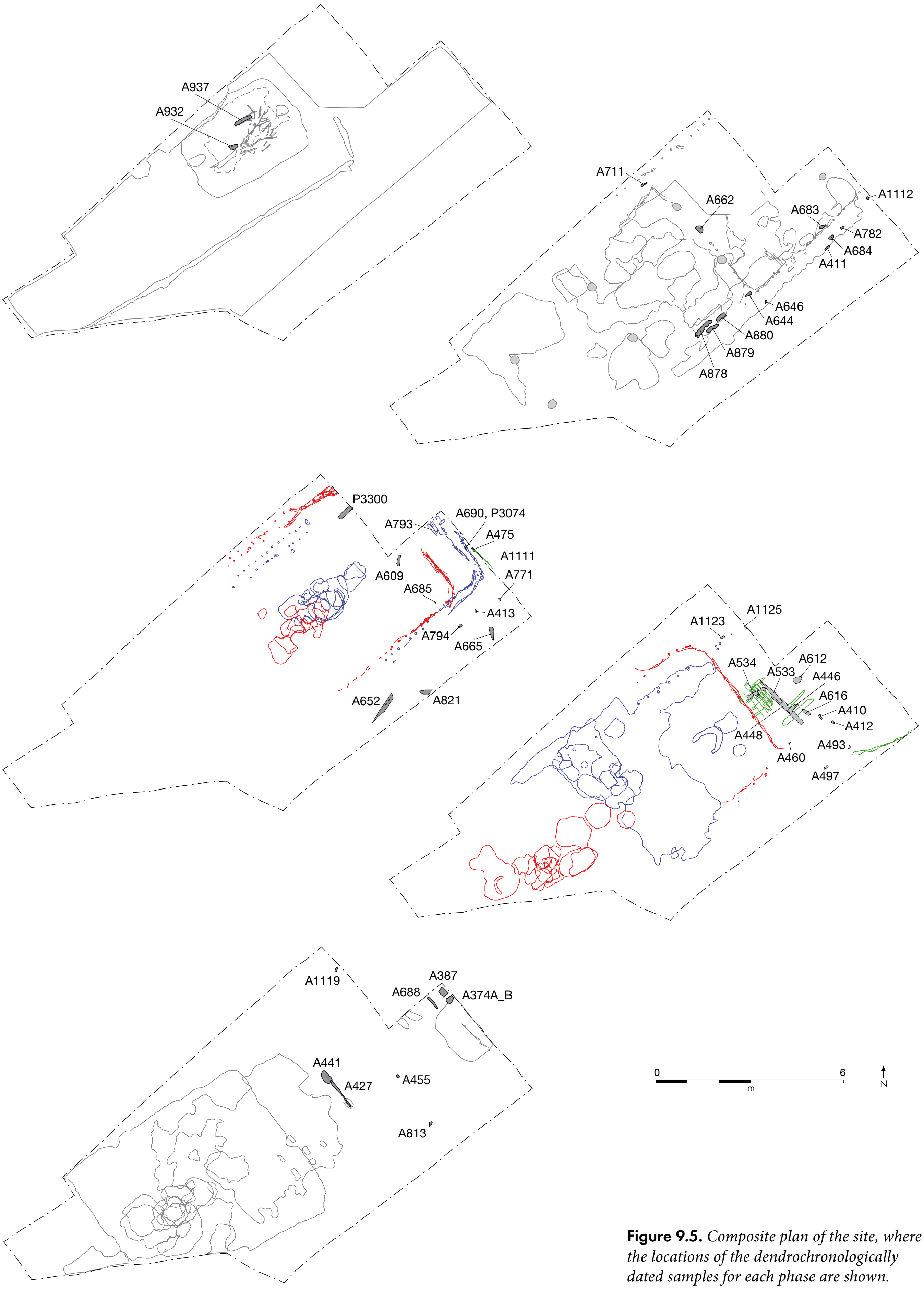

Figure 9.5. *Composite plan of the site, where the locations of the dendrochronologically dated samples for each phase are shown.*

Conclusion

The dendrochronological analysis of the oaks from Ribe has permitted several insights into the usage of the wood resource in the early town, and also allows us to estimate the duration of the timber structures. Although the material was often modified to an extent that makes preservation of sapwood rare, and preservation of bark edge even rarer, by detailed examination of the results in relation to the stratigraphy, we can nevertheless see that rebuilding took place at least every ten years. It seems clear that local resources for oak were used and that reuse of materials from earlier structures was common practice. Wooden structures are most susceptible to rot where the wood is subjected to changing exposure to wet conditions, typically at the place where it meets the soil. Upper structures might still be solid, suitable building material when salvaged from a dismantled building. That this was practised does not indicate a scarcity in resources, for we see that local resources were available for building in the region, also at other sites. The dendrochronological results provide us with the chronological framework for the structures on the site where oak is preserved, and the earliest exact date for felling activity on the site can now be placed at winter AD 707-708.

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