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Chapter 4

Early Medieval Woodland Management and Timber Production in north-western France, 400-1200 CE: The Beginning or The End of Forestry Experiments?

Vincent BERNARD, Isabelle CATTEDDU, Yann COUTURIER and Yannick LE DIGOL

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Abstract:

In contrast to the preceding and following centuries the period 400-1200 CE in north-western France is characterised by a mixed forestry picture, with very old stands arising from the decline of the Roman Empire coexisting with very young coppices designed to meet the needs of wood-intensive activities. This era of silvicultural experiments is expressed in a wide variety of ways on high forest stands (HFS), coppice-with-standards (CWS) or hedgerows in the form of cyclic abrupt growth changes, browsing scars, distinctive tree silhouettes... The holistic dendroarchaeological approach provides indications for forest management and exploitation, adaptive strategies and failures and successes of a nascent silviculture and demonstrates an increasingly assertive customary framework for woodland utilisation, long before the first forestry regulations/rules that came into being in the thirteenth century.

Key words:

Dendro-archaeology, trimming, livestock and skidding bark-stripping, clearing effect,
medieval forestry practices

Early Medieval Forestry: Myth or Reality?

For many authors, silviculture is a discipline that was set up late by scholars, politicians and even landowners whose main concern was to perpetuate a wood resource damaged by individual or communal usages inherited from the past. In a context of important socio-economical transformations and sometimes rapid changes (climatic deterioration, migrations and the arrival of new groups with new agro-sylvo-pastoral and architectural practices, etc.), it was almost naturally that a new type of small, free peasant farms known as *Mansus* ('manse' in French) developed and took hold in western Gaul in the sixth and seventh centuries. These family farms involved irremovable rights of possession or usage in the *ager* (field), *saltus* (*saltus* appears to be a catch-all category, both in terms of plant cover and use, even if pastoral use is in fact predominant) and *silva* (forest). These accesses and usages cover all aspects of rural life, from the grazing of livestock, the collection of fodder, fruit and wild plants, temporary crops, to the right to cut firewood, timber and handicrafts (Devroey 2021, 76; Catteddu 2009, 2012).

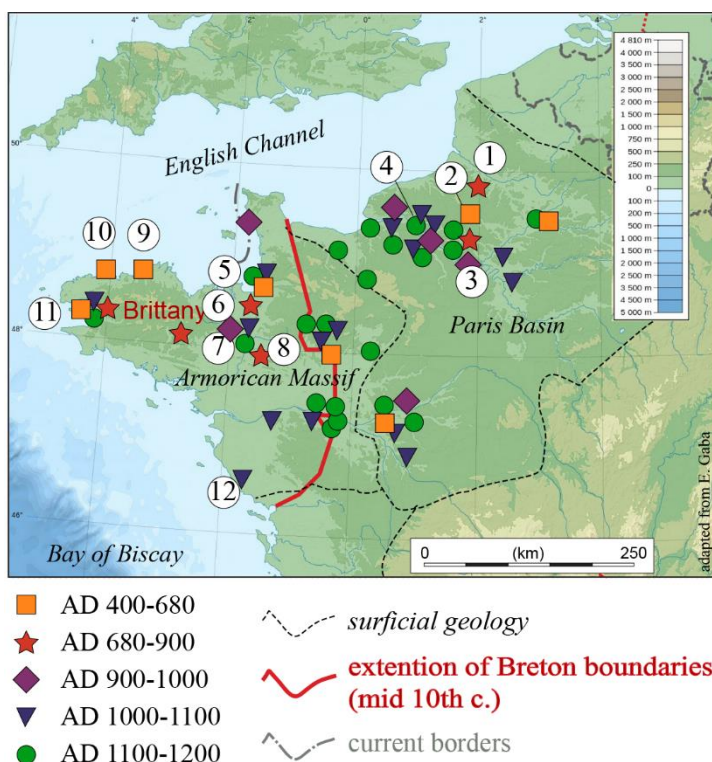
However, from the Carolingian period onwards, these prerogatives were reduced when the elites took possession of considerable portions of forest in a simultaneous movement to restrict peasant usages and protect the forests. Is it a question of forest protection as a hunting reserve, as Beck and Guizard (2019, 112) suggest, or rather an awareness of the importance of this resource and its necessary management? A reading of the capitular *De villis vel curtis imperii*¹ suggests when Charlemagne instructed his stewards to defend the forest against the growth of cultivated land.

In the ninth century, these reserves rose at the same time as the decay of royal authority and the strengthening of seigniorial power to the detriment of the peasantry, a process that was to be amplified from the eleventh to the twelfth centuries (Devroey 2021, 77).

In the following centuries, these restrictions on access to the forests were never accompanied by management and development's programmes for the forest areas, according to the compendia of customs. Does this mean that they are signs of 'forestry that is still in its infancy' (Yante 2019, 213)? In the end, improving yields by optimising the forest area seems to be only a side issue that has been addressed

1 Wolfenbüttel, SB, MS Helmstadet 254, art. 36

belatedly. Indeed, the ordinance and management plans enacted in the seventeenth century by Colbert, in particular for marine timber production, would still tend to pre-date the official entry into the era of modern forestry. According to Bepoix and Gauthier (2019, 205), this would still be 'realistic' forestry in which everyday needs take precedence over abstract anticipation of future needs. This opportunistic view of fuel wood and timber production seems well suited to our study area until the tenth century. In the following period, however, there is increasing evidence for measures directed towards exploitation rhythms that are disconnected from those of architecture.



Archaeological and historical sites quoted in the text:

- | | |
|---------------------------------|---------------------------|
| 1. Saleux | 7. Rennes |
| 2. Auteuil | 8. Chateaugiron |
| 3. Belle-Eglise | 9. Serval |
| 4. Saint-Martin-de-Boscherville | 10. Saint-Pol-de-Léon |
| 5. Champeaux | 11. Landevennec |
| 6. Montours | 12. Talmont-Saint-Hilaire |

[Figure 4.1 goes here, approximately half or quarter page portrait, colour]

Figure 4.1. Map showing the distribution of the dendroarchaeological sites cited in the text in the geological context of north-west France. Map by author.

Actually, what is meant by 'medieval silviculture'? According to F. Epaud (2019, 151), we should speak of 'non-management by man, since these stands do not benefit from any particular treatment, thinning or maintenance of the subjects, other than protection of the plot at the time of its regeneration and maintenance of the coppice's hyper density until the next clear cut [...]'. These protective measures have existed since the royal administration invented the *foresti* in the seventh century, a term that 'first referred to a royal forest, a hunting ground reserved for the king, and then to a territory withdrawn from general use and reserved for the king' (Wirth-Jaillard 2019, 17). The creation of a special corps of local officials, the *forestarii*, marks the institutionalisation of the forest system from 670 CE.

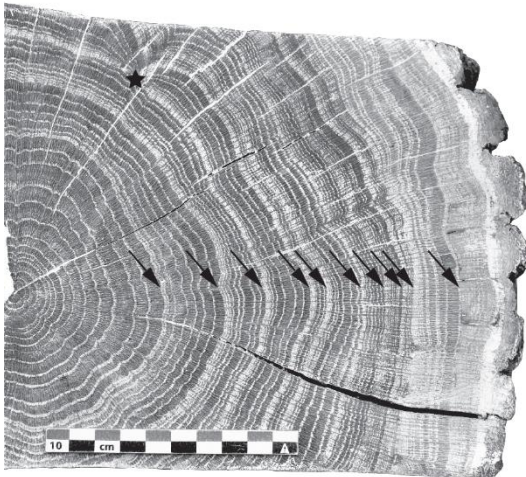
In this case, protecting, is that managing? Not intervening by taking advantage of natural principles of competition, natural pruning, etc., is this not already understanding and apprehending a natural environment in order to anticipate its evolution through a form of 'soft forestry'? In other words, is silviculture necessarily accompanied by highly interventionist actions with planting, pruning, cutting and selecting at different stages of the forest maturity? At that time, even if it seems likely that wood resources could have been put to good use within these protected or even enclosed areas, it is clearly the large wild mammals that are favoured. However, LiDAR surveys in some present-day forest areas show networks of ditches interpreted as the enclosure of forest plots (Epaud 2019; Georges-Leroy *et al.* 2011). Without precise dating of these structures, are they truly ancient and disconnected from post-fifteenth hedgerow systems (*bocage* in French)? In this context, where chronometric dating is lacking almost as much as archaeological evidence, perhaps the selection of isolated straight trees, selective felling favouring natural seed trees or coppice-with-standards (CWS), or on the contrary massive felling favouring coppicing, should not be seen as empirical silvicultural practices acquired since human communities have been felling trees?

The historian D. Wilson (2004, 1) establishes from a critical examination of the legal documents of the first three Anglo-Norman kings (1066-1135 CE) that the large landowners practised 'conscious forest management' to balance the different forms of the forest resources use. However, Anglo-Norman forestry in this period could be seen as a series of flukes, unforeseen events, mistakes and even negligence that

placed hunting above all other considerations (Wilson 2004, 2). In the same vein, if the forest historian G. Peterken (1993, 15) notes a series of measures aimed at preserving English forests since at least 1184 to ensure the timber supply, he summarises their management in terms of 'logging and praying for natural regeneration to follow'. In this context, how can we interpret the 'no waste' clause in the charters issued by the Anglo-Norman King Henry I from 1122 CE onwards, if not the affirmation of the need to repress all forms of abuse and to regulate wood cutting (Wilson 2004, 3)?

In recognising the value of all the woodland resources in twelfth century England, did not other similar strategies emerge earlier on the other side of the Channel, in Normandy and Brittany in particular, before being introduced into England from 1066 CE? Indeed, the role of foresters in protecting trees and undergrowth seems to be well established in Normandy in the eleventh century. They had to be consulted to identify and authorise the felling of mature trees. Their function extended to monitoring, protecting and enforcing the use of forest resources, whether in the context of grazing rights or firewood removals, in order to preserve the forest's integrity and retain the largest timber (Wilson 2004, 9).

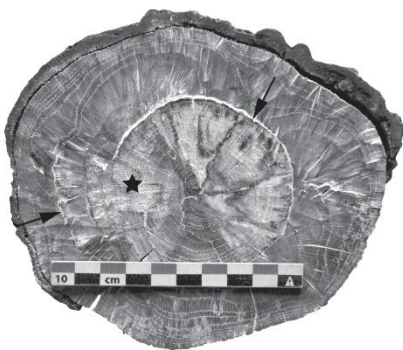
Thus, it seems that foresters in the Middle Ages - or earlier periods - practised silviculture without knowing it. Was it not until the term 'silviculture' was coined that this discipline was finally born? The Gordian knot of this question lies in the ability of ancient populations to produce material with well-established standards - e.g. length, section, and shape - and to anticipate particular needs. Did the medieval foresters have this knowledge and these uses? This is what we will try to establish here, even if pre- and protohistoric examples give some clues by showing forms of trees protecting, hoarding and shaping for specific needs, over several human generations as early as 2400 BCE (Bernard 2008).



(A) POLLARDING / SHREDDING

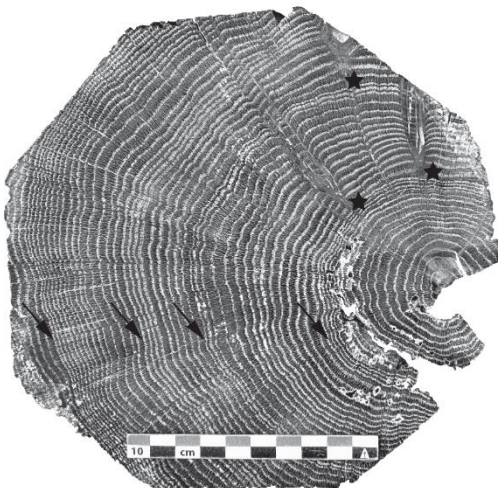
- ↘ Abrupt growth change:
 - year -1: large ring (2.5-4.5 mm)
 - year 0: early wood (EW) complete, late wood (LW) almost absent
 - year +1: EW and LW very narrow
 - year +2: proportion of EW continues to decrease, proportion of LW increases a little
 - year +3: EW and LW start to grow again
 - year +4: complete ring structure similar to year -1 (Bernard et al. 2006, 107).

★ Epicormic shoot



(B) LIVESTOCK BARK-STRIPPING

- ★ Edge of callous tissue overgrowing a stem wound (concentration of parenchymal cells)
- ↘ Wooden part damaged by microorganisms



(C) CLEARING EFFECT

- ↘ Abrupt growth release in a tree which has been freed from competition (cf. Kaennel & Schweingruber 1995, 67).
- ★ Epicormic shoot

[Figure 4.2 goes here, approximately full or half page portrait, black & white]

The results that will be discussed now are based on a dendroarchaeological approach including:

- The main felling phases through well-preserved outer rings,

- Dendrotypological arguments including e.g. pith dates, ages or growth rates of trees (Billamboz 1992).

The diversity of sites and woods studied per chronological period is considerable. Fortunately, Landévennec and Rennes have about 500 samples covering long time intervals with tenth century timbers old enough to date back to the eighth-ninth centuries. The situation improved greatly from the tenth century onwards, and the end of the twelfth and the beginning of the thirteenth centuries, the final stage of this study, saw a return to coppicing concurrently with the advent of Gothic architecture and the rise of metallurgy.

In addition to allowing a particularly detailed and nuanced dating of archaeological structures, these criteria also provide information on forest management and tree selection.

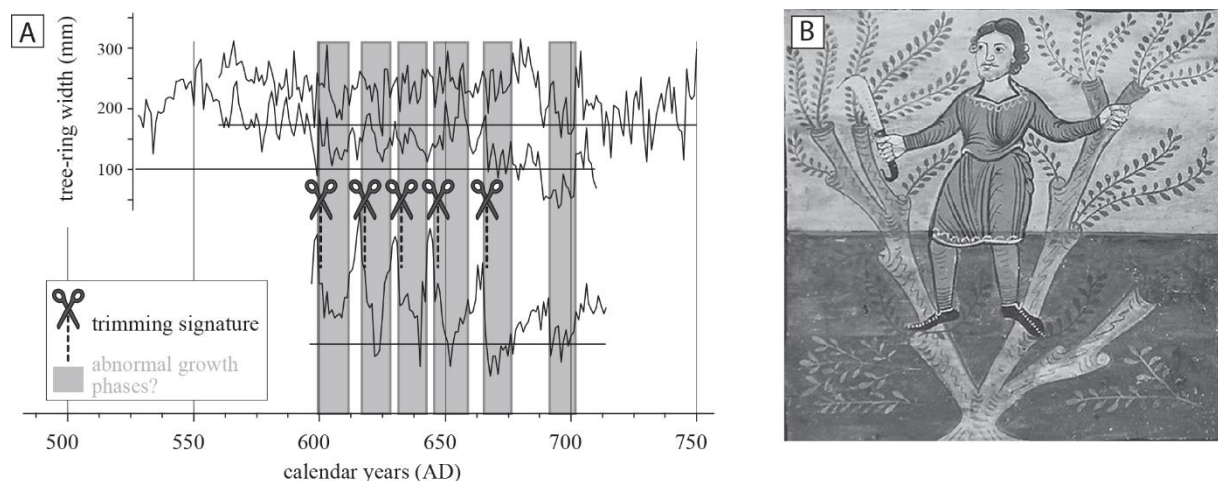
These analyses also take into account various anatomical, physiological, morphological anomalies of the wood and the tree, comprising:

- Identification of the trimming dendrological signature (Bernard *et al.* 2006; Fig. 4.2A),
- Recording of wounding and debarking events related to logging or livestock grazing (Edvardsson *et al.* 2021; Grosclaude 1993, 444; Shigo and Marx 1977; Shigo 1984; Fig. 4.2B)
- Detection of release events related to forest opening (Muigg *et al.* 2020; Nowacki and Abrams 1997; Fig. 4.2C).

Trimming: A Practice Revived in the Early Middle Ages

Within our corpus, some oaks differ from typical forest trees in that they are more compact, with a much lower gravity centre, and the branches develop either at the top of a stubby trunk ('têtard' in French, 'pollard' in English), or on the whole trunk, which is more slender but rarely exceeds 7-8 m ('ragole' in French, 'shredded tree' in English). These trees used in construction, frequently sinuous, covered with numerous knots, twig burrs or cankers, indicate that the branches - all or part of them - were cut regularly to let light into the undergrowth to promote the growth of grassland, but also to produce faggots, possibly fodder and litter (Bernard *et al.*

2007a). This partial or total loss of the tree's photosynthetic apparatus results in abrupt growth suppressions at a more or less fixed rate depending on the period. This practice has certainly existed since the appearance of animal husbandry; examples from the Late Neolithic are proof of this (see e.g. Billard and Bernard 2016, 311-314). During the Early Middle Ages, it reappeared timidly in Brittany around the abbey of Landevennec as early as 600 CE (Fig. 4.3A), in Picardy in 820 (Bernard 1998) where these trees were found alongside poles from fast-growing coppices, but also, as in the Breton example, very old oaks of 200 years and more. It was in the eleventh-twelfth centuries that trimming developed strongly, around Rennes somewhere after 1000 CE, in the Bayeux region possibly as early as 1020 (Bernard *et al.* 2007b) or in south-east England around 1180 (Goodburn 1994). However, there is nothing comparable with the situation in the fifteenth century with the advent of 'bocage' networks and the development of hedges in western France (Antoine 2002).

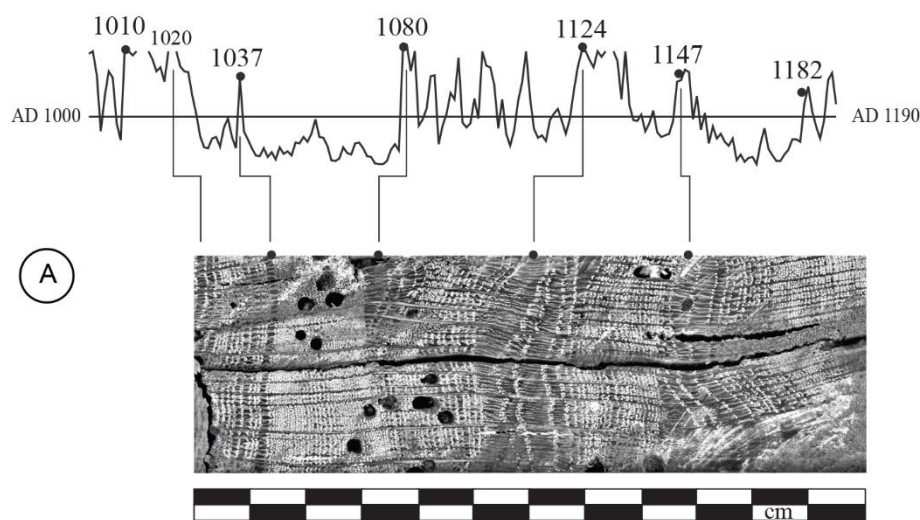


[Figure 4.3 goes here, approximately full width of the page, black & white]

These last two examples deserve some clarification:

- The case of Bayeux is interesting because the studied elements synthesise different agro-sylvo-forestry practices such as trimming with abrupt cyclical growth suppressions followed by sudden release events together with wounds (debarking caused by ruminants or horses? See below). These anatomical disturbances can be associated with forest grazing by dendrotypological and ethno-cultural comparisons (Fig. 4.4). However, the morphology of the Bayeux belfry timbers (c. 1200 CE) clearly shows very old gnarled trees with tortuous grain. And since in 1220, the cathedral

frameworks as well as those of the canons' houses surrounding it will only use this type of material, we can consider that an open woodland was favoured both for the production of branches and timber and for the protection of the animals. These branches had to be cut regularly - the rhythm is not yet regular and varies from 17 to 44 years - and could occasionally feed the ruminants and horses in a semi-free range keeping. Although medieval iconography frequently shows goats grazing on foliage, archaeology provides evidence of optimal use of the products harvested in the forest, in the undergrowth, in the hedges or on the heathlands through all sorts of suitably-sized branches (Bernard *et al.* 2019; Out *et al.* 2017; O'Sullivan 1998).



[Figure 4.4 goes here, approximately full or quarter page portrait, black & white]

- With regard to trimming in England, historians and archaeologists agree that the Anglo-Normans practised firewood collecting via coppicing and pollarding (Goodburn 1994, 659-661; Rackham 2003, 5; Wilson 2004, 3-4). However, we have previously discussed the likelihood of Anglo-Norman technical transfers in forestry from the continent, as has been considered in hydraulic technology for instance (Bernard *et al.* 2016, 352). If none of the dendrological signals are earlier than 1180 CE - which would seem surprising given the general context - it is likely that pruning was popularised at least from 1066 CE onwards if the Bayeux Tapestry and its depictions of pollarded trees on both sides of the Channel are considered to have some truth.

From an anatomical point of view, trimmed trees found in north-western France show three to four successive branch cutting cycles. The cutting interval, from 6 to 17 years, is still irregular, while that described for oaks found in London seems to be better regulated (13-16 years; Goodburn 1994). These differences may reflect the harvesting of varying sizes of products or more random pruning, as other resources may be available. Indeed, it is likely that during the medieval period in general and the Early Middle Ages in particular, there was a greater variety of tree forms, branching and foliage harvesting seasons, taking into account the wide range of tree species suitable for trimming or coppicing for multiple purposes. This is what xylological and anthracological studies in particular tend to show (O'Sullivan 1998; Out *et al.* 2017). However, oak trees in our corpus indicate a single harvesting season, the dormancy season (autumn/winter).

Livestock in the Forest: Silvopastoral Management Only or Management of Usage Conflicts As Well?

Our corpus is also characterised by the presence of bark wounds, which often affect oak trees for large pieces, and oak, chestnut, elm and ash trees for smaller ones, as in the case of stakes from the eighth century at Serval and the eleventh century at Talmont-Saint-Hilaire (Fig. 4.5A, B, E). These wounds concern only part of the circumference, never the whole; in the case of small sections, the observation of a bent pole foot, a decentred pith and therefore reaction wood proves that they are stump sprouts. Indeed, the high density of the shoots limits the accessibility to the bark, which constrains the livestock bark-stripping to the edge of the stand. No

architectural timber with bark wound(s) is preserved long enough to determine precisely the extent of the uprooting or the shape of the two ends. However, where a starter is preserved, no tool marks are visible and the rounded shape is similar to goat bark-stripping left in archaeological experiments (Fig. 4.5F). Debarking of wild animals such as red deer is different enough to be ruled out (Edvardsson *et al.* 2021). Concerning the small sections used as piles (≤ 10 cm and ≤ 20 years), only one wound is present and the felling of the young tree mostly takes place 1-3 years later. It would therefore appear that livestock access to these plots is allowed after a minimum of 15-20 years regenerating, shortly before the harvesting of coppice poles, perhaps once an utilisation is determined and a felling schedule agreed. Fourteenth-century Norman historical records state that the grazing ban should extend for at least twelve to fifteen years (Roquelet 1984, 49). It is obvious that below these age and pole size thresholds, interest in architectural uses is limited.

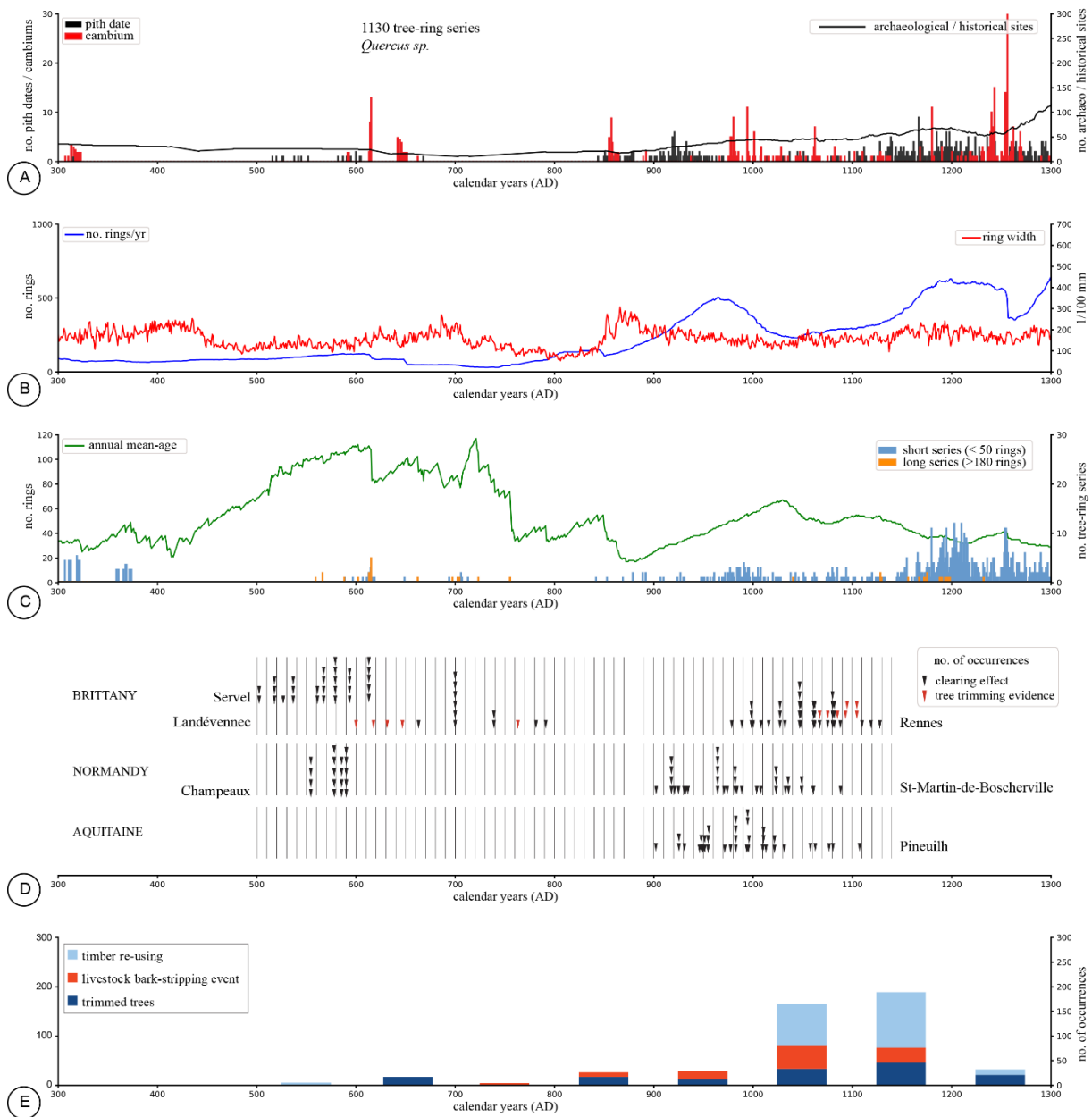


[Figure 4.5 goes here, approximately full or quarter page portrait, colour]

Among the larger woods (> 20 cm), multiple wounds are not uncommon, sometimes up to five with frequencies of 1 to 15 years (Fig. 4.5D). Oak trees affected by this damage also have a particular morphology: they are often gnarled, rarely straight and their rapid growth suggests that they come from pasture-woodlands where the livestock found them particularly interesting: their bark and foliage, their annually mown twig burrs, but also their trunks for rubbing. This explains why some of the trees are very damaged, and because of the frequency of bark removal, the exposed wood could hardly heal, which explains the attacks of microorganisms, the rotten

areas and the cankers that follow. This poor quality confines these woods to basic functions where they are at best squared, but certainly not split and made into planks; before the pitsaw came back into use at the end of the fourteenth century in north-western France, this would be perfectly impossible because of the many knots. It is perhaps also because these woods are damaged or because their shape is not always easy to incorporate into a construction that a preliminary selection was carried out in order to keep only the healthy elements compatible with the requirements of a craftsman. These defects are therefore relatively unobtrusive and many of them probably ended up as firewood. This practice changed fundamentally during the sixteenth century with a very marked use of this type of tree in Breton frameworks (Bernard *et al.* 2007a).

On the basis of a hundred or so occurrences, it seems that livestock bark-stripping appears timidly in Brittany during the eighth century at the latest, reaching a peak in the eleventh century and disappearing in the thirteenth. It would be tempting to see this signal stop as the growing influence of central power and local elites to protect these areas and the resources they contain. However, it is interesting to note that the livestock bark-stripping event trend is roughly in line with that of trimming, but also with that of timber re-use (Fig. 4.6E), further indicating a period of shortage in timber supply. It would be more accurate to consider that new rights of use were established progressively, at a time when, locally, wood reserves were dwindling (eleventh-twelfth century). It would certainly be naïve to imagine that from the thirteenth century onwards, restrictions on access to the woodlands were aimed solely at ensuring the continuity of these areas, even though large landowners were taking over large estates. From this time on, the opening up of the forest environment became more a matter for the woodcutters than for the livestock breeders.



[Figure 4.6 goes here, full page portrait, colour]

These conflicts of use were expressed in different ways, and as early as the seventh century, rules are recorded in texts and archaeological evidence establishes a convincing parallel through the discovery of enclosures, slopes, hedges², and even *feంగా* (Schmidt-Wiegand 1977, 418). The *Edictus Rothar*³, written in 643, refers to this cattle path, a fenced passage, which allowed damage-free livestock movements

2 ² Wolfenbüttel, SB, MS Helmstadet 254, art. 3650, 56, 66

3 ³ St. Gallen, Stiftsbibliothek, Cod. Sang. 730, § 253, 291, 372

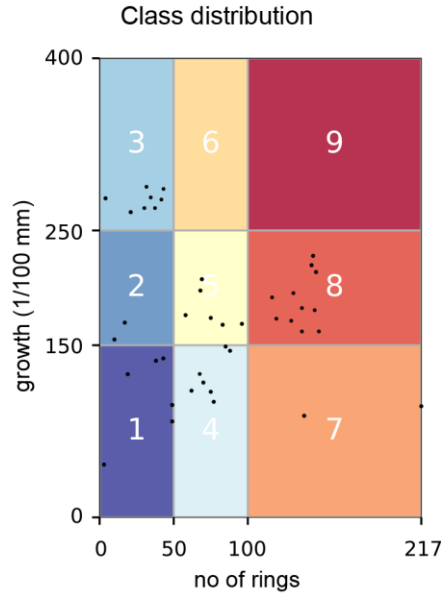
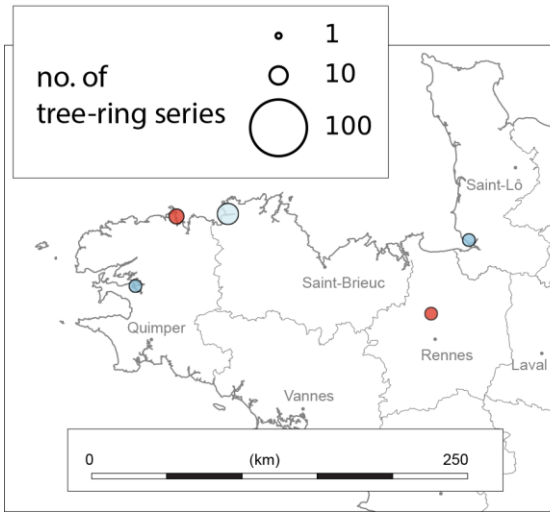
and linked settlements and pastures. But let us not forget that the use of the forest for livestock and timber production had to be balanced with the practice of hunting. Count William of Normandy had a parcel of land enclosed where vegetation could grow higher than in the surrounding wood-pasture in order to protect deer habitat (Wilson 2004, 7). Relative tolerance is given here to pigs, but not to horses and goats, which are detrimental to woodland regeneration and must be closely watched. Yet, despite these restrictions, the size of domestic animals in many European countries reached a minimum in the eighth and ninth centuries, attributed to the semi-free grazing of cattle. Stable isotope analyses could be one of several pieces of evidence (Grau-Sologestoa 2015, 132).

In the centuries that followed, disputes, litigation and court cases were to multiply over questions of access to the undergrowth and the movement of livestock in the forest (Duceppe-Lamarre 2006, 60-61). As Wilson (2004, 7) argues, was conflict resolution not an integral part of the active management of the medieval forest?

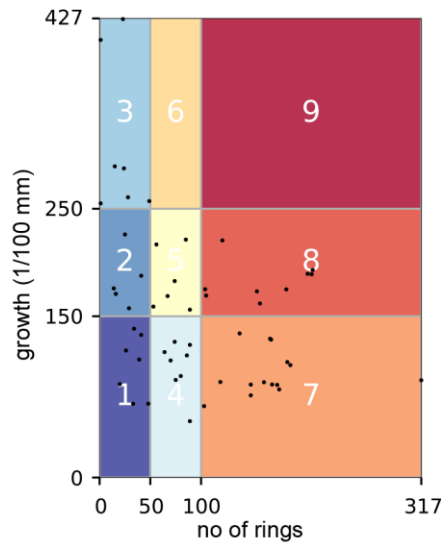
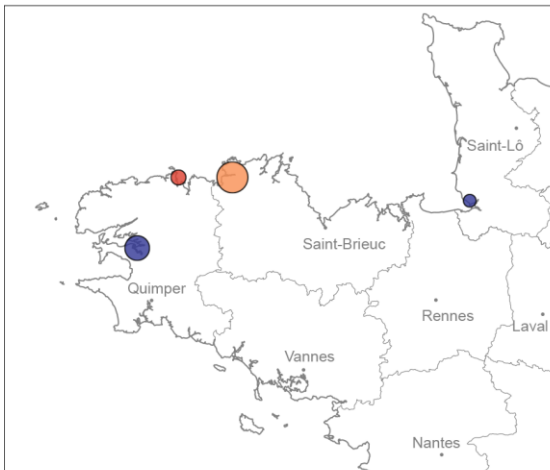
Overmature Oaks in the Early Middle Ages?

The Early Middle Ages present a mosaic of extremely contrasting landscape and forestry forms (Fig. 4.6A & B; Fig. 4.7), which is suggested by a corpus that is nonetheless less extensive than for the first-second centuries or the tenth-thirteenth centuries, for example. Archaeobotanical analyses are fairly scarce and most often report on open environments where wooded areas are absent or far from the palynological sampling zones (Gaudin 2010, 455).

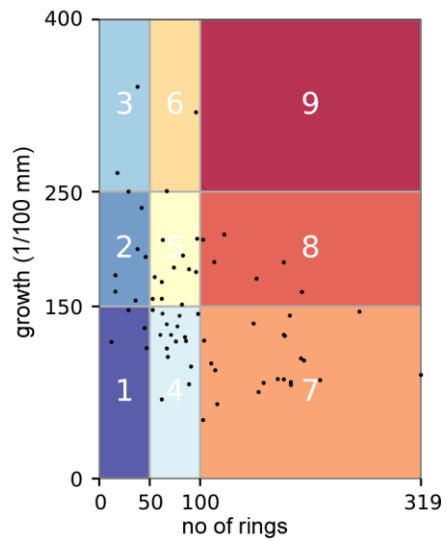
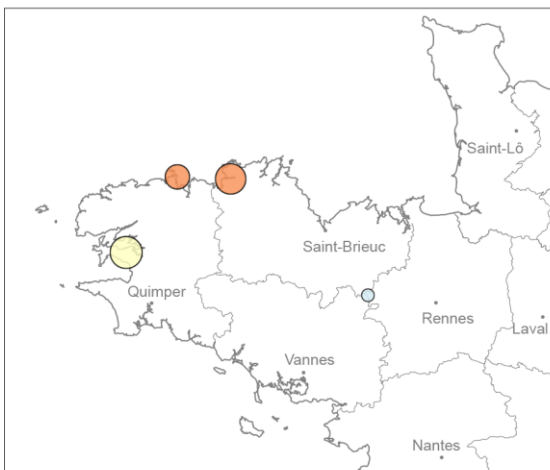
AD 400-500 36 tree-ring series



AD 500-600 56 tree-ring series



AD 600-700 68 tree-ring series



[Figure 4.7 goes here, approximately full page portrait, colour]

The first centuries of the Middle Ages include few sites, but their nature is often highly original (Fig. 4.1), even unique, such as the Merovingian wells at Auteuil (Bernard 1998), the fishweirs of an unknown design at Serval (Bernard and Langouët 2014), the oldest tide mill at Saint-Pol-de-Léon (Bernard *et al.* 2021), or the former abbey at Landevennec.

All these archaeological sites have in common the use of oversized and overmatured oak trees born in the Late Roman Empire (240-420 CE), in a period of declining agro-sylvo-pastoral activity “due to the migration of peoples , leading to an extensive reforestation” exactly as mentioned by Billamboz and Becker (2001, 850) in southern Germany; all these trees were felled during the seventh century.

Of course, the entire forest of the sixth-seventh centuries was not composed exclusively of this type of tree, since some coastal areas, such as the Bay of Mont-Saint-Michel with the fishweirs of Champeaux dating from the 600s, show vast areas of oak coppice entirely devoted to the construction and maintenance of fishing structures. This phenomenon developed in north-western Europe at the instigation of the abbeys, from the end of the sixth century in Normandy and Brittany (Bernard and Langouët 2014; Billard and Bernard 2016) and from the eighth century in Ireland and Britain (O’Sullivan 2001). According to ancient woodland specialists and historians, coppice stands were generally made up of a single species growing from regularly spaced stumps, among which could be larger 'standards' grown for timber. Coppicing greatly increases the amount of wood produced by the tree. Thus, a smaller coppice area is needed to meet demands that would otherwise require extensive clearing (Rackham 2003, 3-5; 137-144; Wilson 2004, 3-4).

However, the use of very large and very old oaks, unheard of since the Neolithic period, raises questions: since these trees were not predominant in the landscape, why were they felled over such a short period of time (Fig. 4.6C)? Apart from Auteuil and the Beauvais area, where there are no hagiographic or historical records before the ninth century (Fémolant 1999, 147), Breton oaks seem to be associated with areas strongly marked by the arrival of saints from across the Channel and christianisation during the second wave of migration by Britons between the fifth and seventh centuries. Although later, many Lives of Saints in north-western Europe are

full of miraculous episodes involving evangelists grappling with sacred trees, objects of pagan cults, such as that of St Martin and St Boniface (Dowden 2000; Popineau 2007, 104; Rio 2001). Less well known is the story of Saint Carantec in Brittany, which relates his confrontation with the local lord Dulcinius in order to take possession of Callot Island - opposite Saint-Pol-de-Léon - and set up his hermitage there. It is at the price of the divine lightning of a giant oak tree that the 'true' faith can be imposed.

In Alsace, similar trees used as well liners have been observed in the same chronological context, but a completely different interpretation is given, favouring the utilisation of low-value wood (Peytreman 2018). As for the archaeological remains from northwest France described above and discovered as common lumber, can they be considered as witnesses of this early medieval Christianisation surge? The presence of very large trunks was obviously an opportunity for all kinds of architectural production (Billamboz and Becker 2001) and the use of hollow oaks is widely underestimated among ancient populations (Bernard *et al.* 2008). Although the archaeological and historical evidence is scant, these isolated trees may have played an important role in the materialisation of boundaries, such as calvaries or megaliths, which they sometimes replaced (Bonhomme-Trogno 2005; Popineau 2007). Thus, at Châteaugiron in Brittany, a large windthrow area separates the hamlets of site A (west) from the hamlet of site B (east; Catteddu 2013, 204). Only a path links the two occupations through this possibly woodland. A line of north-south ditches delimits the inhabited occupation of site A to the east and separates it from this woody area. This early medieval separation would be maintained until the modern period, but with a bypass that corresponds to the location of a huge windfall. It therefore seems likely that over the centuries this tree was respected and circumvented, perhaps in association with another landmark. These landscape elements were easily identifiable by their position, their age, their name or the cult attached to them (Popineau 2007, 104). Their eradication from the landscape becomes all the more fascinating.

Eighth and Ninth Centuries: the first stirrings?

Until the eighth century, neither the very strong demands on coastal forest resources, nor the expansion of farms in the previous centuries which led to the growth of villages, nor the development of metallurgical or naval activities seemed to jeopardise the forest balance, thanks to an alternation in the use of young and old trees, oaks and less technical quality wood (Bernard *et al.* 2019; Catteddu 2017; Fig. 4.6A & C). In the Paris Basin, the rate of felling accelerated so rapidly that it seems difficult to find an oak tree over 40 years old in the middle of the ninth century, whereas the largest trees selected a century earlier were already no older than 80 years. The anthracological results from the excavations of early medieval sites in Brittany all highlight a mosaic of landscapes with a clear importance of coppice, wet meadows and heathlands favourable to livestock farming. The specific nature of the fuels used according to the type of fuelwood - oak for metallurgical furnaces, mixtures of open environment species (such as broom and gorse) for domestic fireplaces - clearly illustrates the extensive and perfectly controlled exploitation of the different biotopes accessible to humans and herds. No plant resources seem to have been wasted, judging by the composition of the fodder and litter remains discovered on the seventh-eighth century settlement sites of Montours and Châteaugiron (eastern Brittany; Catteddu 2001; 2012, 106, 134-138, 2013; 2017, 342): it is generally a mixture of fern, broom, rye straw and branches. As historians have pointed out, cultivated plots, heaths, undergrowth, edges and now hedges constitute a polymorphous set of environments and resources for which archaeological and archaeobotanical evidence is accumulating to testify to the antiquity and adaptability of agro-sylvo-pastoral practices.

In order to link farms, hamlets and villages to the various farming and grazing areas, to connect the farms between them, but also and above all to delimit and restrict the livestock's routes, essential ditches were dug from the beginning of the Early Middle Ages. In these networks integrating farms, paths, ditches, enclosures bordered by embankments and/or vegetation (thorny hedges, oak), fords, etc., circulation spaces and gateways were created for the livestock; but it is the remains of fodder and litter that suggest the existence of stabling areas (Catteddu 2001; 2012; 2013; 2017). While the hypothesis of hedge tree plantations has been formulated for the Carolingian village of Montours located between Rennes and Avranches (Catteddu 2001), or around the ninth-century enclosure ditch of Saint-Denis (north of Paris;

Dietrich 1991), in Picardy, oaks from hedgerows or slopes were used as timber in the hydraulic mills and settlement structures of Saleux around 780 and Belle-Eglise in 820 CE (Bernard 1998). A more rigorous settlement and land patterning is visible in the west as well as across the Channel, most clearly in the eighth century throughout our study area, where a wide variety of wood resources are used for crafts, architecture and livestock. In the course of the ninth and tenth centuries, there was a transfer of craft activities, particularly metallurgy, to places closer to the raw materials. Many elite settlements were also built in the heart of wooded areas, or even forests. Some of them bear witness to the presence of metallurgical activities (forge) or even charcoal-making activities (Burnouf and Catteddu 2015).

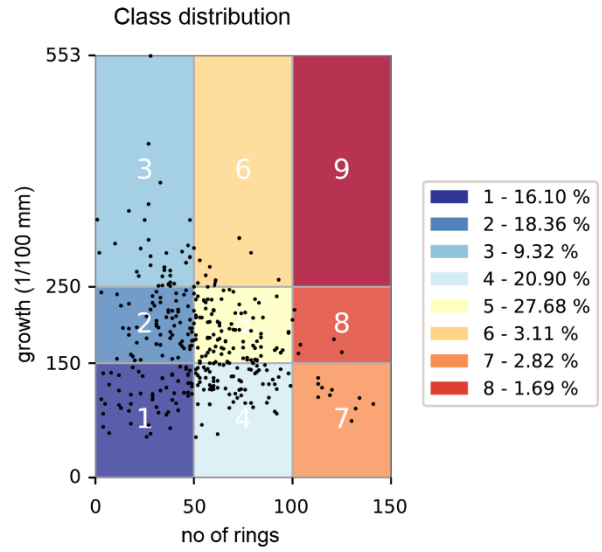
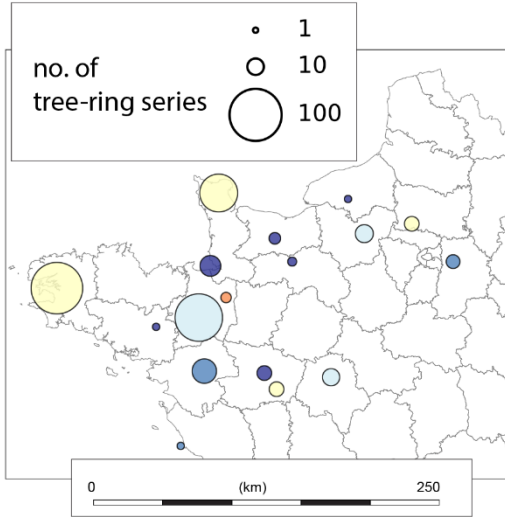
It is in this context of extraordinary development of villages and parcel networks, economic growth, demographic boom, but also rise in power of local rural elites that appear in the ninth-tenth centuries in north-western France the evidence of specific forest treatments that we will qualify as 'silviculture' despite the precociousness of the signals.

Tenth to Twelfth Centuries: Rhythms of the Forests, Rhythms of the Buildings?

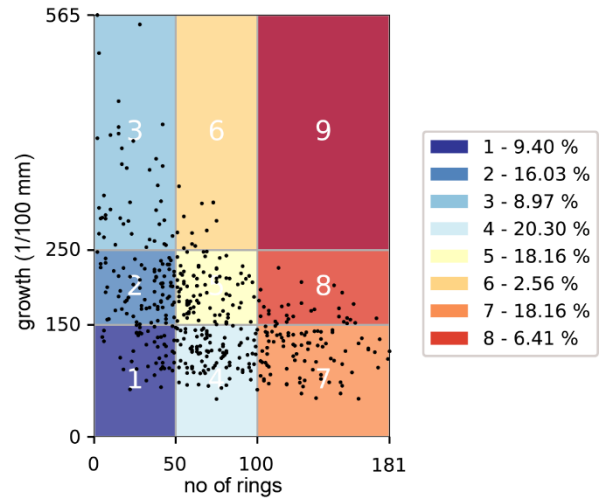
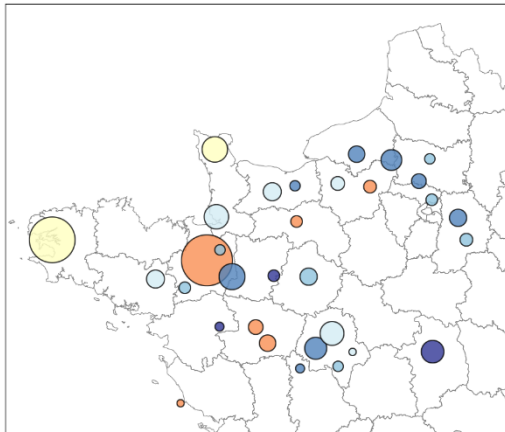
The main part of our reflection on woodlands in the years 900-1200 CE is based on the timber of Romanesque and early Gothic structures thanks to the old oaks they sometimes used (Fig. 4.6; Fig. 4.8). If the end of this sequence is marked by a period of intense coppicing (Bernard *et al.* 2007b; 2019), before reaching this situation, different trends will develop during 300 years to settle or disappear. Thus, between 900 and 1000, oaks are on the whole young to mature (30-80 years) with moderate to slow growth. Between 1000 and 1100, the situation remains stable at the end of the Armorican peninsula and Cotentin; on the other hand, an ageing of oaks is noticeable around Rennes, although spots of more dynamic growth trees (< 50 years old) are established here as in the Paris Basin. These trends were confirmed during the following century, as practically all old oaks (100-250 years) were located in the west in Brittany and Normandy, whereas elsewhere, oak populations experienced a very strong rejuvenation with very rapid growth. This ushered in the 'Gothic era of coppicing', a period marked by an unprecedented architectural and urban rise, economic and demographic boom that required the rapid production of perfectly

sized trees in short cycles (Bernard *et al.* 2007b; 2019). It was not until 1450 CE that this trend came to a halt and the forest aged.

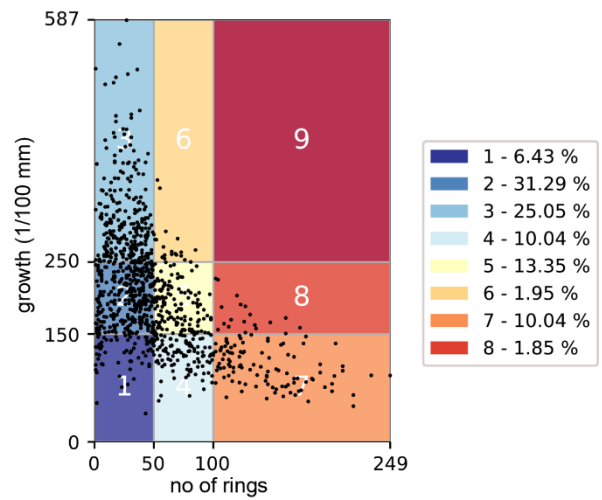
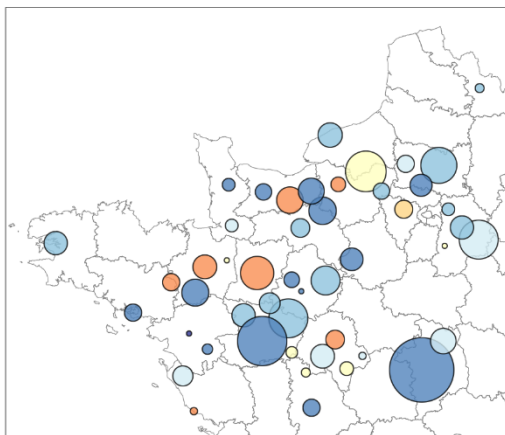
AD 900-1000 354 tree-ring series



AD 1000-1100 468 tree-ring series



AD 1100-1200 1026 tree-ring series



[Figure 4.8 goes here, approximately full page portrait, colour]

Whether it be the Brionne keep in Normandy in the middle of the twelfth century, the Laval castle in Mayenne around 1222, the Saint-Germain district in Rennes between 1080 and 1129 or the abbeys of Saint-Martin-de-Boscherville near Rouen around 1150 and Paimpont (40 km west of Rennes) around 1230, the builders chose large, slow-growing oaks over 200 years old, the product of strong competition with the younger trees in the understorey. However, the architecture has not always kept track of these young trees. These examples involved large quantities of old oaks (several dozen, even several hundred) with large sections (50-70 cm), some of which were split for planks, others squared to obtain long structural pieces (8-12 m). Such a large number of fully-grown trees necessarily implies that the forest plots were managed as high forest stands (HFS). This means that before producing these oaks with slender, branchless shafts, it was necessary to select the promising tillers, to trim them, to remove the ill-conformed, forked or twisted plants, and then to control the density around the selected trees.

Coppice-with-standards (CWS) is an empirical silvicultural practice based on simple natural principles: by allowing light to enter the plot after removing dominated or low-value trees, it promotes seed germination and forest regeneration on the one hand, and the radial growth of trees left standing as seed trees on the other. This treatment explains why old, relatively slow-growing trees can stand alongside trees much more dynamic in their development. Thus, the trees preserved within a CWS forest are two, three, four times older than the coppice trees: among the architectural pieces, at Bonport Abbey near Rouen (Bernard *et al.* 2007b, 24-25), in the coastal fishweirs of Saint-Pair-sur-Mer in Normandy or Serval in Brittany (Bernard *et al.* 2013, 162-164), there is a mixture of oak - and soft wood in the fishweirs - of 15, 30, 60 years old, and in a much smaller proportion, mature oaks of 120, even 180 years old. The largest of these will be used primarily as long-span tie beams, or more modestly as split piles, while the youngest will be used for all other parts of the structure. A complete cycle time of forestry exploitation is generally around 120 to 130 years, which implies two rotations of 60 years (Bonport) to eight of 15 years (fishweirs) depending on the final destination of the timber. The annual maintenance of the fishtraps involves shorter rotations due to the rapid erosion of the structures in a coastal context. If the rules of exploitation were gradually established during the eleventh-twelfth centuries, 8 to 10

tillers per acre had to be preserved in order to ensure the renewal and durability of the forest surface. It is therefore not surprising that the few seed bearers felled at the end of the cycle are in such a minority, and in the end represent barely 5 to 10% of the trees used. The situation is the same from Normandy to the southwest of France around the elite site of Pineuilh occupied from 977 CE to the end of the twelfth century (Bernard *et al.* 2012).

All these treatments were recorded in the oak tree-rings of the years 900-1200 CE for almost 200 years. Thus, in their juvenile phases, some edges of callous tissue accompanied by abrupt growth suppressions suggest the trimming, but they correspond to the shaping of the trees by pruning. In the following years, the regular harvesting of the understorey poles temporarily relieves the pressure around the future trees, which appears in cycles of brief release events. During this period, the falling or hauling of the removed trees during thinning may have caused injuries to the standing trees. These wounds appear simultaneously, at different heights⁴, at a regular rhythm of about ten years, and concomitantly with release events and twig burrs formation. This strongly indicates the human origin of these signals. The exceptional sampling of complete sections at each end of the beams of the former abbey church of Saint-Martin-de-Boscherville documents this particular case. The reason for this is that these anomalies are not visible around the entire girth of the tree and require an overall view to be highlighted. This correlation between anomalies in several trees and regular openings in the forest suggests that these trees probably belong to the same plot. The example of Saint-Martin-de-Boscherville, after that of Paimpont mentioned earlier, could therefore be seen as a rare case of selection and reserve of large seed trees from the 10th century, well before the first forestry regulations of the thirteenth and fourteenth centuries.

The trees of Rennes, which cover the tenth, eleventh and part of the twelfth century, also show a ten-year rhythm of thinning cycles that constitute the background noise, a sort of high-frequency signal of undergrowth management. Every 20-30 years the signal intensifies (medium frequency signal) probably due to more extensive forestry

4 At Saint-Martin-de-Boscherville, the dendro sampling was done at the foot and head of the timbers, where the wood was preserved.

work resulting in the felling of more middle-aged trees mature for construction (60-100 years; section > 25 cm). Finally, the low-frequency signal of the early medieval logging is still tuned to the major construction phases, which include the death of large seed oaks of about 200 years. If the correlation between forest management and architecture is strong during this period, the early and rigorous forestry in Normandy and Brittany must be linked to an estate management by large landowners. Thus, it is assumed that the Boscherville forest may have been given by Duke Robert the Magnificent (1027-1035) to Rabel, a member of the family of chamberlains of Normandy and officer commanding the ducal fleet (Bernard *et al.* 2007b, 26-30). Similarly, the oaks of Rennes appear to have come from the forest of the same name, owned by the Counts of Rennes who all became Dukes of Brittany from the end of the tenth century.

Synthesis

The various arguments set out above show that the rhythms of forestry exploitation in the Early Middle Ages were still constrained by those of an architecture belonging to a 'wood civilisation' (Devroey 2021, 77). In fact, the sixth and eighth centuries hardly show any kind of desire to optimise forestry areas with a view to their long-term future. The forest exploitation, the felling that was organised, and the times imposed on these spaces were therefore, like the buildings erected for a ruling class, the expression of the temporal power that it held. If the period 400-500 CE is characterised by a majority of young coppice poles with fast/very fast growth widely spread in the north-western quarter of France, very old oak trees (~ 8% of the corpus) are mainly from the Armorican Massif. Between 500 and 650 CE, the presence of old oaks increases within (or alongside) more dynamic forest stands. Christianisation was certainly also a driving force behind the changes in the forests, as in the tip of Brittany where, as early as 600 CE, oversized and overmatured (pagan?) oaks disappeared; the simultaneous reintroduction of trimming and logging cycles began to punctuate the woodland regeneration around the abbeys (Fig. 4.6D & E). Until the tenth century, the correlation between forest (including wood-material and wood-energy) and architecture seems difficult to refute. In fact, with the development of craftsmanship, demographic and agricultural growth, the rise in power of the elites, the multiplication and development of monasteries and

settlements (end of the seventh to ninth century), the pressure on natural resources intensified considerably, revealing all the complexity of human relationships in which the rights of usage relating to the forest became one of the manifestations.

Although the rules for woodland management were imposed in the Early Middle Ages, partly in order to resolve the many conflicts of usage, wood production, in particular timber production, which must meet specific criteria, is still conditioned by the diameter/height ratio of the bole. This very strong constraint certainly weighed on the forest resource to lead the owners out of the immutable vicious circle of 'harvesting-regeneration-maturation-harvesting'. Indeed, this practice repeatedly causes a decline in large trees, the coppice development and a necessary abandonment of surfaces to ensure their renewal and durability. Awareness seems to be emerging (see capitular *De Villis* under Charlemagne), but it is not accompanied by a top-down political decision imposed on the whole territory. Indeed, until the thirteenth century, the royal forests were still essentially hunting grounds. The coercive efforts in the forests of Normandy and Brittany, which began in 900 CE, therefore most probably were the work of local elites, or even powerful lords: a relative of the Duke of Normandy in Saint-Martin-de-Boscherville or the Duke of Brittany himself in Rennes.

This major stage in the history of the forests emerged punctually, but synchronously, during the tenth century in the western part of France, where CWS plots were thinned at a rate of about ten years. This type of treatment by regular interval cuts, recorded by most of the trees, clearly demonstrates that the same areas have been managed for several cycles, i.e. for several decades, according to a predetermined pattern or taking into account the history of the treatments. The evidence of numerous dendrological signals related to various forms of forest management tends to demonstrate that these areas were the sites of early silvicultural experimentation, the exercise of which may have been introduced in England from 1066 CE.

What is the relationship between these still experimental silvicultural adjustments and the presence, punctual or not, of herds of domestic animals, sometimes tolerated in the regenerating plots? Livestock, apart from horses, often forbidden in these areas, reach their minimum size in the eighth-ninth century, which may be associated with

the consumption of nutrient-poor woody plants (Grau-Sologestoa 2015)⁵. This trend in much of Western Europe confirms the historical view of daily animal runs through a multitude of landscape forms including *saltus* and *silva*. Despite the negative aspects of harsh forestry rules and lawsuits for animal roaming, foresters have inevitably found the value of livestock regularly clearing undergrowth to make felling and hauling trees easier, and even to ensure regeneration and forest diversity (if this can be a medieval dimension!). In the New Forest (southern England), where pasture-woodlands are still used by livestock, ecologists have established that the main factor in the elimination of grazing-sensitive species is the combination of grazing and wood harvesting rather than grazing alone (Sanderson 1993, 113). The main effect of grazing is to reduce the density of trees in grazed woodlands. This produces more varied and open conditions than ungrazed HFS, which is more uniform and less favourable to species diversity in grazed woodland. It turns out that the spaces between trees are as important as the trees in the grazed woods. Finally, tree trimming is an excellent opportunity to maintain a good level of productivity in these environments, but for oaks that are rarely straight or tall. On the other hand, it is understandable that, from the Gothic era around 1180 CE, the production of very long, very straight and suitably-sized trees leads to the hyper density of coppices (Epaud 2019, 144-148) where no room can be made for livestock. This disappearance of the grazing dendrological signal could therefore be a marker of profound changes in forest management with more rigorous fencing ('mise en défens' in French). However, while the first official forestry rules date back to this period, grazing bans for horses and sheep/goats do not always seem to be well respected (Beck and Guizard 2019, 116).

The question of the age of the CWS practice in the north-western quarter of France must be asked. Indeed, although Muigg *et al.* (2020) situate its appearance in Germany and Eastern France in the thirteenth century, this silvicultural technique is well established in Brittany, Normandy and the Paris Basin in the eleventh-twelfth centuries. The question here is not where and when the oldest CWS signal appears - for any forest manager quickly and pragmatically understands that density and light,

5 ⁴ Selection, crossbreeding with Germanic cattle, new breeding practices, adaptation to wet grasslands in times of climatic crisis are other answers to a difficult question.

subsoil nature, selected species, etc., are all parameters that impose their own rules; it is therefore a very old form of silvicultural management, probably dating back several thousand years - but why this model has imposed itself on such vast territories in such a short time. This revival in forestry, with dense coppicing and more productive CWS over shorter periods of time, occurred with the emergence of the great cathedrals and castles, the urban boom, and the rise of wood-intensive crafts and metallurgy. Given the close links between forest management and architectural cycles until the end of the twelfth century, was the Medieval Warm Period not sufficiently intense - considering all the societal changes it brought about - to also become the driving force behind profound changes in the organisation of forests and the cultivation of oak trees? If regularity is emerging in forest management here and there from the 900s onwards, a background noise persists in the dendro-silvicultural signal, proof that these forests are still multi-purpose. From 1180 CE, the rhythms of the HFS will become those of the foresters and this forest dedicated to architecture is properly an invention of this period. However, the numerous lawsuits for cattle wandering or illegal logging are a reminder that the demands of daily life or the needs of increasingly wood-hungry craftsmen still have to be met with this old versatile forest model, but also within this new more restrictive model.

We have already answered the question of whether architecture has influenced silviculture on several occasions (Bernard *et al.* 2007a; 2007b). And the dendroarchaeological studies carried out in north-western France indicate that the answer must be nuanced. If we can answer enthusiastically yes for the Paris Basin where all the indicators point in this direction, in Brittany, where other landscape systems have developed because the soils are poor, the forests are thin and the winds are sometimes violent, timber production has turned to hedgerow trees that are often shorter and sometimes twisted, and Gothic architecture has had to adapt. Thus, in the Armorican peninsula, local conditions imposed a new type of timber on this new style of construction: the medieval buildings are less wide in western Brittany (6 m on average), where the winds are most intense, than in the east (6.80 m; Olivier 2020, 148-149). This means that some churches or castles were obliged to limit the width of their edifices or to cheat to increase the prestige of the owner by using forked timber for example to optimize the useful length of the tree (Bernard *et al.* 2019, 249).

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Figure captions:

Figure 4.1. Map showing the distribution of the dendroarchaeological sites cited in the text in the geological context of north-west France. Map by author.

Figure 4.2. Typology of dendrological signals related to early medieval forestry and used in the text. Photo by the authors.

Figure 4.3. Trimming practice. A) Trimming effects on oak trees: example of the Landevennec site. B) Representation of trimming with a billhook around 1140 CE; scene from 'Zacchae in the sycamore', Saint-Martin-en-Zillis (Switzerland). Photo by the authors.

Figure 4.4. Oak in an agro-sylvo-pastoral context. A) Cyclic growth anomalies in a beam from the Bayeux belfry. B) Beam from the Bayeux belfry showing knots and twisted wood grain on its surface. C) View of a present-day Breton oak showing morphological characteristics common to those of the Bayeux belfry beams. Photos and chart by the authors.

Figure 4.5. Architectural timber and tree showing the characteristics of live-stock bark-stripping. A) Oak stake from the eighth-century Serval fishweirs. B) Elm stake from the eleventh/twelfth-century harbour of Talmont-Saint-Hilaire. C) Oak pile from the Saint-Germain district in Rennes, eleventh/twelfth century. D) Section of an architectural oak piece from the hydraulic mill of Colomby, 1002 CE. White arrows indicate multiple injuries. E) Growth fall in an elm stake in Talmont-Saint-Hilaire, eleventh-twelfth century. F) Oak debarked by goats; Melrand archaeological farm, Brittany. Photos and chart by the authors.

Figure 4.6. Diagrams of the main dendrological characteristics discussed in the text for the period 300-1300 CE. Gaps in dendroarchaeological sites and low sample replication in the mid-seventh and mid-eighth centuries can be bridged with old timbers from later centuries. A) Curve representing the number of tree-ring dated sites as well as forest regeneration phases (pith date) and felling and construction phases (cambium). B) Master chronology (red) and curve of the number of dated woods per year (sample replication; blue). C) Oak average age (green) and phases of young (blue) and old (orange) trees.

Figure 4.6. Diagrams of the main dendrological characteristics discussed in the text for the period 300-1300 CE (continued).

D) Signs of early medieval silvicultural practices for some sites mentioned in the text. E) Centennial trend diagram for the evidence of trimming (dark blue), livestock bark stripping (orange) and timber re-use (light blue).

Charts by the authors.

Figure 4.7. Maps and scatter plots of the main dendrological characteristics of fifth, sixth and seventh century oaks in Brittany. The colour code used here corresponds to the most represented age classes (number of rings)/growth rate (1/100 mm). Class 1 corresponds to young trees (<50 years old) with slow growth (<150 mm/year), interpreted as dominant trees in the understorey of a high forest; class 3 groups young trees (<50 years) with very fast growth (>250 mm/year) as coppice trees (stump sprouting type); class 7 includes the oldest trees (>100 years) with slow growth (<150 mm/year), such as old seed trees from high forest. The scatter plot represents the distribution of the corpus according to these characteristics. . Maps by the authors.

Figure 4.8. Maps and scatter plots of the main dendrological characteristics of tenth, eleventh and twelfth century oaks. The colour code here is the same as for the previous figure. For the chronological sequence covered here, areas with young poles of fast/very fast growing coppice will gradually become more important, but old growth stands will resist, especially in the West. Maps by the authors.