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WHAT DO DENDROCHRONOLOGY AND OTHER TIMBER-DATING METHODS TELL US ABOUT THE HISTORY OF ENGLISH POST MILLS?

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Post mills are a distinctive type of windmill that has had a long history in England. Today only 47 post mills still survive in England. Evidence from 15 of these where their timbers have been subjected to dendrochronological investigations combined with other sources of evidence helps build a picture of the history of each of these mills. Most mills contain timbers from different historical rebuilding phases, but with the main posts often being the oldest component. Bourn Windmill was the earliest of these (the tree from which the main post was made being felled sometime after 1515) but Nutley and Pitstone mills retain almost equally ancient main posts. Scientific timber-dating methods can help corroborate the historical narrative derived from other evidence, such as documentary sources or inscriptions; however, they can also help raise completely new questions, illuminating stages in the history of a structure that were previously unknown or unsuspected.

KEYWORDS: *post mills; windmill history; dendrochronology; oxygen isotope dendrochronology; radiocarbon dating*

INTRODUCTION

One of the first questions that members of the public ask when visiting a post mill is its age. Many mills have claimed to be the oldest in the country, sometimes based on written records of the existence of a mill on the site, sometimes on the typology of the mill construction, and sometimes on physical evidence such as inscribed dates. However, in the last few decades, dendrochronological dating of various post-mill timbers has shown that most mills contain a collection of parts from several different ages.

This paper attempts to summarise what we know concerning the history of post mills in England and how this understanding can be informed by dendrochronology and other timber-dating methods.

There are essentially four main sources of information that can help shed light on such matters:

- the typology of the mill structure—whether it is of a known ancient design or the timbers from which it is built incorporate recognisably ancient architectural (or sometimes mechanical) features;
- maps, deeds, paintings and other historic documents that establish or indicate the presence of a mill at a certain location at an earlier date in history and sometimes also details of its structure and how this may have changed;
- carved dates, initials, names and other inscriptions or graffiti on timbers in a mill that seem to indicate a particular (or at least minimum) age for such components;
- scientific dating of timbers, either by conventional tree-ring width sequence matching or more recent methods using oxygen-isotope analyses and wiggle-match radiocarbon dating.

This paper evaluates how such sources can help build a picture of the history of particular mills. It also considers what conclusions can be drawn as to how post-mill technology and architecture in England has changed historically over time.

The paper draws on evidence from fifteen post mills (almost a third of those surviving in England), where their timbers have been subjected to dendrochronological investigations in recent years.

EARLY HISTORY OF ENGLISH WINDMILLS

THE DEVELOPMENT OF WIND POWER

Before windmills appeared, watermills had existed for millennia and were quite common and widespread throughout England where there were suitable

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watercourses to power them. If they were on a good water supply, they often continued to prove more reliable than the windmills, which were vulnerable to the intermittent nature of the wind. On the other hand, watermills had a tendency to flood; maintenance of watercourses, mill ponds and disputes over water rights were some of the many issues faced by water millers. On the whole, many watermill sites were prized and some such mills, once developed, were maintained in the same location over many centuries.

However, not everywhere has an adequate water supply, and windmills thus provided a new opportunity to spread the capacity to grind flour to many remote or dispersed rural communities situated well away from significant watercourses. Despite the difficulties of an unpredictable wind supply, many windmills provided millers with a good living over many generations. Millers were frequently proud of the mills, whether they were driven by wind or water.

The post mill is distinguished as a class of windmill by the fact that the main body of the mill, which carries the sails and millstones, is rotated bodily about a vertical axis, the main post, in order to face the wind (see Fig. 1). The other main class of corn-grinding windmill which survives in England and elsewhere in Europe is the tower windmill (and including the subset of these—the wooden tower windmill known as the smock windmill). In a tower or smock windmill the millstones are in the fixed tower; the cap carries the sails on the top of the tower and only this cap and the sails turn to face the wind. The concept of this cap has a current-day analogy in the nacelle of modern wind turbines.

For reliable and efficient milling, the millstones must be kept horizontal at all times and their drive shafts (stone spindles) must be vertical. One disadvantage of post mills is that this can be difficult to sustain in an old, distorted mill body which is continually being turned to face the wind around an often not quite vertical post. Tower or smock windmills had the clear advantage of mounting the millstones and auxiliary machinery in a fixed tower, were more spacious and less likely to distort seriously with age. Even if the tower did become a little distorted over the years, the millstones and stone spindles could generally be adjusted to run true and remain true over extended timescales, irrespective of the wind direction.

THE FIRST WINDMILLS

Although there had been a number of watermills and horse mills involved in the grinding of grains since at least Roman times, no windmills existed in England before and including the eleventh century. The Domesday Book of 1086 mentions some 6,000 different mills but, as far as we know, none of these were windmills.

The place of origin of the post-mill design remains unknown. Three positive references from the 1180s have a wide geographical spread in England, indicating that by this date the design had established a strong foothold.[1] These early mills stood at Dinton (Buckinghamshire), Amberley (Sussex) and Weedley (Yorkshire), and there were no doubt other contemporary examples which did not enter the documentary record. In one well-documented early legal case in 1191, Abbot Samson of Bury St Edmunds ordered the destruction of a windmill that had been built on glebe land without his permission.[2]

These early mills were probably light and unstable, having earth-fast posts often buried in a mound. Rot, along with the impact of rocking and general wear and tear, meant that they probably needed replacing every 50–60 years. More than twenty sites of ‘sunk’ post mills with buried trestles (see below) have been excavated in England.[3] Such archaeological evidence shows that the design of the early trestles varied considerably.

A splendid and much-quoted illustration of an early post mill is to be found on a memorial brass in St Margaret’s Church, King’s Lynn Minster, Norfolk, dedicated to the mayor of the town, Adam de Walkosen, who died of the Black Death in 1349. It shows that the structure of the post-mill buck and tailpole (for terms, see next section) and of the trestle were already well established by this time. The original late twelfth-century post-mill design was so successful and adaptable that new post mills were still being built almost 700 years later. At Wetheringsett, Suffolk, a completely new post mill was erected on the site of its collapsed predecessor in 1883.[4]

At least by soon after 1515, and probably earlier, post mills like Bourn (Fig. 2) with main posts at least 14 ft 6 in (4.42 m) in length were being constructed. These larger, taller structures were significantly heavier, and their ‘trestle’ timbers could be placed above ground, often on brick piers, thereby increasing the span of their sails and thus the power they could generate, but also reducing the rate of decay of the trestle.

The small, early post mills had the advantage of relatively simple construction. The trestle needed to be strong and well constructed, since any movement in the trestle could be amplified over time, leading to sudden collapse. But the trestle required relatively few timbers, admittedly of excellent strength and quality. Once the design requirements were understood the timbers could be worked up reasonably quickly, and techniques were soon developed for renewing major trestle timbers. Having said this, the larger post mills were much more difficult to construct and required expert millwrights.

A HISTORICAL PERSPECTIVE

Post mills have a long history in England, stretching from the late twelfth century until the last days of

commercial flour milling by wind in the mid twentieth century. However, many post mills were replaced in the latter part of this period by tower and smock mills, often in the same locations.

For almost eight hundred years, traditional windmills of these various kinds were a familiar and prominent feature of the landscape, performing the vital function of grinding corn to feed the population and, in some areas, draining low-lying marshland. They were predominant in providing such milling services in areas less suited to waterpower, but mechanical improvements during the early industrial revolution meant that windmills could still compete effectively in many areas.

In the mid to late nineteenth century, windmills lost ground to steam power, partly because of the unreliability of the wind, but also because of the difficulty in scaling up traditional designs to higher powers. The design loads of traditional windmills were typically measured in tens of kilowatts, whereas steam plant rapidly increased in size to hundreds of kW, then to megawatts.

Interest in wind power has not gone away, despite the lean times for windmills during much of the twentieth century. Considerable market interest has been revived in recent years into stone-ground flour and a Traditional Corn Millers Guild has been formed, bringing together those involved in sustaining historical milling skills, using mills powered by wind or water.

The use of windmills to generate electricity was developed from the 1890s in Denmark, a country without exploitable coal.[5] Starting from traditional windmill designs, new materials were introduced, and large mills with openwork iron towers were soon developed ('iron smocks' colloquially).

Development of wind power has accelerated since the 1980s, with the awareness that it can make a major contribution to a more sustainable world electricity system, emphasising the importance of renewably sourced power. With the application of optimal engineering materials to ever longer wind turbine blades, to improved gearboxes and to multi-pole generators, wind turbines in the megawatt class are now routine.

DESCRIPTION OF THE STRUCTURE OF A TYPICAL POST MILL

THE TRESTLE

The post-mill concept is a marvel of late medieval carpentry while being very simple in essence (see Fig. 1). It consists of two main parts—a central main post held upright in a braced trestle sitting on low brick plinths. The main post supports a box-like superstructure or mill body which is balanced on the top of the post and is thus able to rotate through a full 360^0. In East Anglia, the mill body was known as the buck, which is a convenient term that has been used throughout this paper.

The sails, which convert the force of the wind into motive power, are carried at the front of the mill buck, inside of which is contained all the milling machinery. At the rear of the buck is the main door which is accessible from ground level by a sloping ladder. A long lever, the tailpole, projects through the ladder so that its outer end is within easy reach of the ground.

In order to work, a windmill's sails must always face the wind, so the miller's first task was to rotate the buck on its post, so it faced the right way. To do this, the miller pushed the end of the tailpole, first raising the feet of the ladder clear of the ground. Whenever the wind changed, the miller had to pause and descend the ladder to turn the mill into the wind (known as 'luffing' the mill). In later post mills, the tailpole was replaced with a fantail and its carriage which enabled the mill to automatically trim itself into the wind (see, for example, Fig. 13).

Later millwrights constructed larger and taller post mills. In addition to being more powerful, these were significantly heavier and better able to withstand strong winds. Their trestle timbers could therefore be placed above the mound rather than set within it, and to achieve this were raised above ground level on brick piers.

The trestle supporting the main post comprises two horizontal cross trees, which act as tiebeams, and four sloping struts known as quarter bars. The weight of the mill itself is carried by the main post and is divided equally between the quarter bars, passing this force down through the cross tree ends into ingenious, so-called bird's-mouth joints and so to four brick piers which support the whole of the trestle, including the main post above ground level. Sometimes the trestle is attached to the piers with metal tie bars but often this stability is achieved, particularly in the larger heavier mills, purely by the overall downward weight of the structure itself.[6]

THE POST MILL FRAMEWORK

The crown tree is a substantial timber that rests on top of the main post like the top stroke of a T. Longitudinal side girts are carried horizontally at either end of the crown tree, and four vertical corner posts are hung on the side girt ends. This forms the basis on which the rest of the buck is constructed. Horizontal wall plates or upper side rails span between the shoulders of the corner posts on either side, with lower side rails connecting their lower ends. In the Midlands, northern and western areas of England, many post mills had additional timbers in their side wall panels which are referred to in this paper as lower side girts.

At the front and rear of the mill body, three main transverse beams at upper, mid and lower levels connect the side wall frames together. The most important of the transverse beams at the front of the mill is the weather

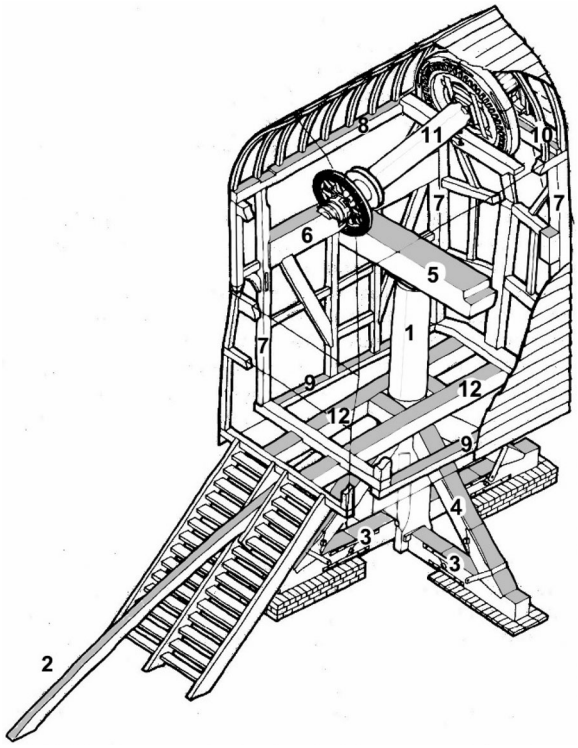

Figure 1. Standard post mill design with principal timbers annotated. Based on a drawing of Gransden Windmill by Graham Black. Key: 1 Central main post; 2 Tailpole; 3 Cross trees; 4 Quarter bars; 5 Crown tree; 6 Side girts; 7 Corner posts; 8 Wallplates, or upper side rails; 9 Lower side rails; 10 Weather beam; 11 Windshaft; 12 Sheers

Figure 2. Bourn Windmill (Cambridgeshire). Note the open trestle supported on brick plinths, pitched roof shape and two plain sails (photo: Martin Davies)

beam which supports the weight of the sails and is therefore necessarily much heavier in section than the others. The sails are attached to the outer end of the windshaft which extends inside the mill and is supported by the weather beam and at its rear end by the tail beam.

The weatherboard cladding of the buck is nailed to the overall frame and to studwork, usually placed vertically, between the main wall frame timbers. Above the upper side rails, pairs of rafters form the lightweight roof of the mill. The rafters were initially straight, as at Bourn Mill (see Figs 2 and 5), but were later curved or ogee-shaped (see Figs 7 and 9) to allow more room for the massive brakewheel that holds the main drive gearing.

The lower floor of the mill body is formed on a pair of longitudinal sheers with short spacing timbers set between them. These heavy timbers form a square at the centre which clasps the waist of the main post, steadying the whole structure.

The millstones, usually one or two pairs, were positioned in front of and behind the crown tree on the upper of the two floors (which is thus known as the Stone Floor, *cf.* the lower floor, often known as the Meal Floor). Taller mills such as Cromer Windmill, Great Chishill Windmill and Windmill Hill Mill, Herstmonceux, had an additional upper floor above the millstones where grain could be stored prior to milling (often thus known as the Bin Floor). Many smaller or more primitive mills did not have this upper floor. Madingley Mill, exceptionally, has two floors but with the millstones positioned on a separate framework on the lower floor of the buck.

THE ROUNDHOUSE

Exposure of post mill trestle timbers to the weather limits the lifespan of these large oak timbers, in spite of frequent re-coating with tar or white lead paint. Later renewal of the cross trees and quarter bar timbers of trestles was found to have occurred at several of the mills in the group studied here. Post mills where the trestle remains unenclosed are referred to as ‘open trestle post mills’. Although once common in England, only six open trestle post mills still survive, four of which are included amongst the mills examined in this current study.

Eventually, the trestle often became protected from the elements by enclosing it in a roundhouse, of brick, stone or timber. This was usually a circular structure with vertical walls and a shallow conical roof

(sometimes with wooden tiles, sometimes even thatched). The apex of the roof was omitted, allowing the main post to pass through it. Thus, neither the roundhouse nor the mill itself depended on the other for structural stability. A roundhouse offered complete weather protection and also provided vital extra storage space (shown in Figs 9 and 11).

The earliest evidence for post mills with roundhouses comes from map depictions from the late 1690s, but this very useful addition to the original design took at least another century to become ubiquitous.[7]

EVOLUTION OF THE POST MILL STRUCTURE

In the early stages of a technology, it is often the case that several distinct design variants develop in parallel, until eventually a dominant design scheme becomes clear.

The main structural engineering requirements are:

- The large main sails must be securely supported at all times, and over the long term. This is quite challenging: on the smallish Gransden Windmill the sail assembly including windshaft and brake wheel is estimated to weigh about 3.5 tonnes, on a larger mill such as Wicken Smock Mill the weight is approximately 5.5 tonnes. The centre of mass of the sail and windshaft assembly will be well forwards, typically just behind the 'neck bearing' at the front of the mill body. This is an awkward task for the millwrights, even in a tower mill.
- The millstones themselves are heavy, of the order 2 tonnes per pair when new, though often post mills employed smaller, lighter stones. Successful flour milling demands that the stones are maintained rigorously horizontal. This is easily ensured in a tower mill, less so in an old post mill, where any weakness in the framing could mean frequent readjustments as the buck is turned to face winds from different directions.
- The wind on the sails can exert a considerable horizontal force, trying to blow the mill over backwards. For example, if Gransden Windmill (a typical early post mill) is caught fully clothed (see Fig. 3) in a 40 mile per hour gust, the nett overturning force exerted by the sails will be of the order of 2 to 3 tonnes.

This was all quite a challenge for the early millwrights, the timber engineers. The main post must be held rigidly upright at all times, and the buck and post must withstand heavy loads and torques, accentuated in storms.

The overturning force due to the wind is broadly proportional to the frontal area of the mill. Ideally, doubling the dimensions of a mill raises the frontal area by a factor of four. But if scaled exactly ideally its weight would increase with the mill's volume by a factor of eight. As an engineering approximation, Paul Jarvis demonstrated that as the scale of a post mill is increased, the overturning wind speed increases.[8] Our understanding is that the overturning speed would increase with the square root of the scale. Lengthening the cross trees out of scale is also important. Indeed, a small post mill can only be made secure by fixing its cross trees to the ground (as is necessary for the small model post mill at Bloxham Grove Mill, Oxfordshire) or—as in past times—by burying the trestle as in a sunk post mill.

A consensus grew up that the post was best supported by strong diagonal braces, the quarter bars. These are tenoned into the post about halfway up (Fig. 1). The weight is transferred down the quarter bars into heavy horizontal foundation beams, the cross trees, near their ends. Horizontal loads are transmitted from the post to the trestle, again partly down the quarter bars, and partly from the foot of the post into the cross trees.

The main post is typically some 2 ft square (600 mm × 600 mm) at the bottom and at Gransden Windmill, for example, it is 17 ft 6 in (5.35 m) long. Such a timber would have been difficult, as well as expensive, to source, so it was not renewed lightly. As will be shown below, when the age of the timbers in a mill is examined, it is often found that the main post is one of the oldest timbers surviving in the mill.

In contrast, the quarter bars and cross trees that form the remainder of the trestle tend to be replaced much more frequently. Generally, there are two cross trees and four quarter bars forming a strongly triangulated trestle with the post, the whole being held off the ground by brick piers (Fig. 2), but occasionally there were more cross trees: for example, Chinnor Mill in Oxfordshire has three cross trees and six quarter bars.

While the sunk post mill was quite soon abandoned, there was greater design variation in the buck. The heart of the buck is the crown tree, a heavy transverse beam sitting on the top of the main post. Historically, the frame of the buck is carried off the crown tree in one of two ways.

Taking an ancient example, Gransden Windmill buck has two horizontal beams, the side girts, running from front to back of the mill (Fig. 14), and carried on the ends of the crown tree. The rest of the body is built up from the side girts by vertical and horizontal frame components. Most of the weight of the sails is taken directly by another heavy transverse timber, the weatherbeam or breast beam. Originally there was little if any diagonal bracing in the buck, as can be seen at Pitstone and Kibworth Harcourt mills: stiffness was provided by tightly fitted joints, and in old age the

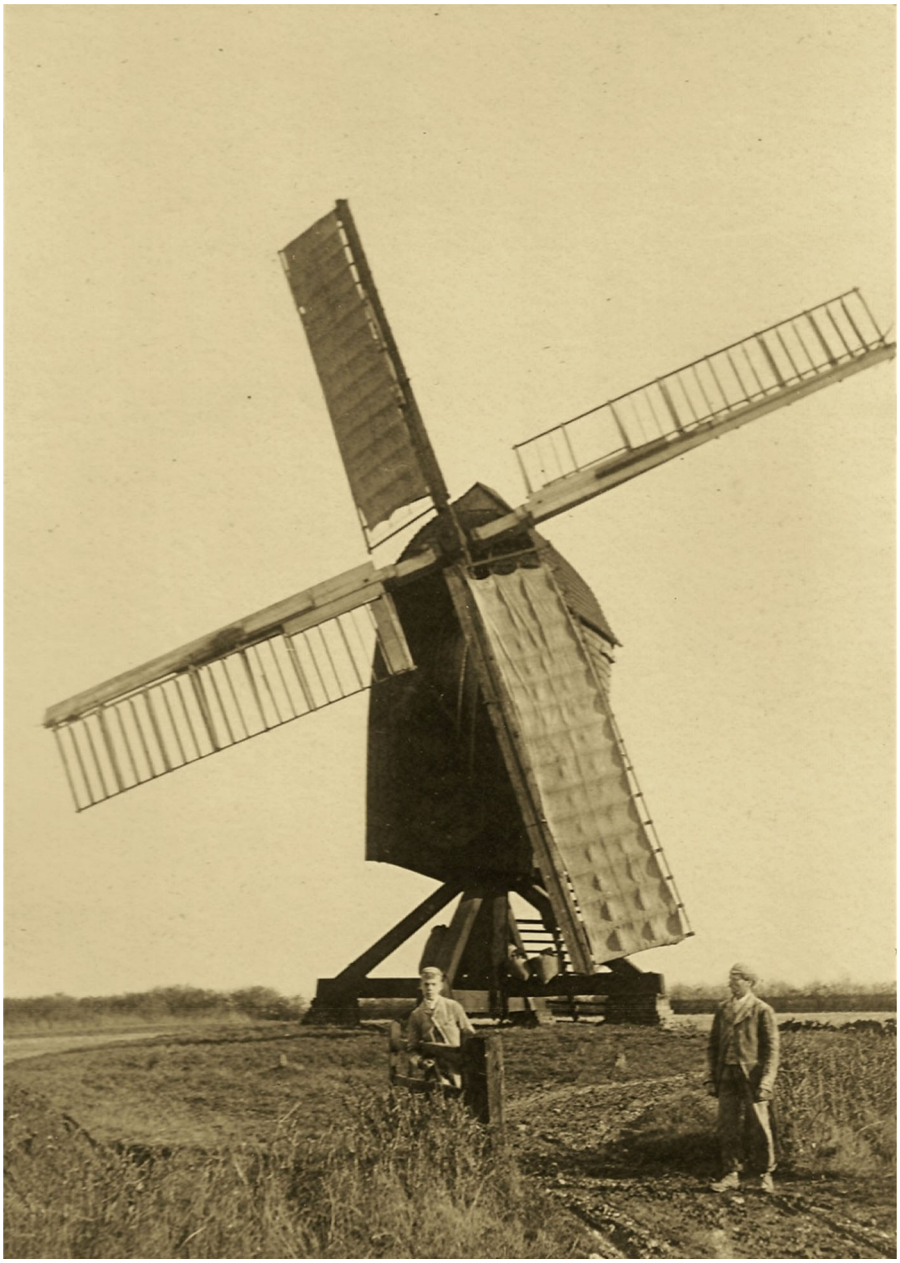

Figure 3. Gransden Windmill in its working days in the early 1870s—a rare early photograph of a typical early post mill. Note the open trestle supported on brick plinths, the two plain sails with cloths unfurled and the curved roof shape (photo: Revd Frederick Le Grice. From Gransden Society Archives)

nailed-on weatherboard cladding itself would often provide some extra strength.

An alternative and contrasting buck design also found favour, and remarkably is still found at two of the ancient post mills in the group examined here: Bourn Windmill and Drinkstone Post Mill. It also survives at Six Mile Bottom Post Mill, Cambridgeshire. The horizontal side girts are replaced by strong vertical posts, set at the crown tree ends. These strong verticals run from top to bottom of the buck side frames (see Figs 5 and 13 of Bourn and Drinkstone). It is interesting also to note that at Six Mile Bottom the vertical posts are doubled up, to clasp the crown tree.

In this alternative design, the weight of the buck is hung from the top side rails, and transferred to the crown tree via the hefty vertical posts. Loading is typically transferred from the top rails partly by heavy diagonal braces. This scheme is perhaps more dependent on stiffness in the joints, and generally the top rails could do with being of heavier section. However, the fact that this ancient design trait has survived so long means that it has sufficient intrinsic good characteristics to be viable long-term. Nonetheless, the design with horizontal side girts certainly became the dominant one.

The value of diagonal bracing gradually became recognised, and later post mills were built with integral

trussed sides. Old mills such as Gransden were retrofitted with diagonals and tie rods in the side frames. At Gransden there was no big move towards diagonal bracing on the stone floor, though.

POST MILLS IN THE UK AND THE SUBSET OF THESE THAT STILL SURVIVES TODAY

It has been estimated that there were some 4,000 windmills in England by 1400.[9] This increased to perhaps somewhere in the region of 7,000–10,000 at their peak in the early nineteenth century. Post mills were widespread and a characteristic sight in most towns and villages, their distribution pervading the whole of the British Isles to a greater or lesser extent, and for hundreds of years they would have been the dominant form of windmill. There is still much historical research to do to fully document their detailed distribution in England and their past dominance in the early centuries of the history of windmills.

With post mills reaching their peak numbers in the late eighteenth century, the nineteenth century saw more efficient smock and tower mills being introduced and then later steam and diesel engines. Post mills suffered further blows to their existence during the First World War when the government declared that conditions within windmills were such that their flour should not be used for human consumption. The loss of millers and their sons killed in battle during the conflict sometimes also spelled the end of working life for the post mill.[10]

The decline can perhaps best be illustrated by reference to a few counties where this history of mills has been particularly well studied. It has been estimated that in Suffolk in 1783 there were 200 post mills and that by 1840 70% of the 500 windmills (so *c.* 350) in the county would have been post mills.[11] The decline began in the early twentieth century: in 1900, 157 post mills were still standing in the county, at which time most were still working. They reduced in number rapidly as they fell out of use and by 1950 only 26 remained standing.[12] Post mills in Suffolk were still being lost in the 1960s when preservation efforts began in earnest, and today only seven post mills survive in Suffolk.

In the adjacent county of Essex there were also a very considerable number of windmills. In Volume 1 of Ken Farries' remarkable five-volume magnum opus on the history of windmills in Essex he presents intriguing data from a variety of sources.[13] In 1800 there were approximately 225 windmills of all types in the county, of which about 150 were post mills. The number increased to a maximum of about 275 mills in 1825, of which about 175 were post mills. However, by 1875 the total windmills had reduced to around 225 again, of which 136 were post mills. After that the decline accelerated, such that by about 1895 there were 150 windmills in Essex, including 80 post mills. Finally, by 1975 there were only about 25 complete windmills surviving in Essex, including seven post mills.

Apling studied the history of windmills in Norfolk.[14] He found that, although a combined total of 949 windmills had been recorded in the county by 1981, only half of Norfolk's 750 parishes ever had a windmill—but many had more than one, or a succession. Smock and tower mills were relatively late to appear, the earliest known example of a smock mill being the remains of the base at Briningham, built in 1721. Post mills had a stronghold here until the late eighteenth century and probably until the early nineteenth but then were quickly replaced. Today there are only three post mills in the county (two of which are rebuilds and one a completely newly built mill).

Lincolnshire would have had a very similar pattern to Norfolk, with the vast majority of post mills replaced by tower mills during the early nineteenth century. Dolman also reports that by the late eighteenth century it was common practice to enclose the trestle of Lincolnshire post mills in a brick roundhouse.[15]

With many post mills being lost, from the 1950s onwards and in some cases even earlier, a movement arose in the latter part of the twentieth century to conserve these local landmarks, some mills being taken over by local community-led or windmill enthusiast trusts, others by local authorities and still others remaining in private hands.

Early examples include Bourn Mill where the mill was gifted to the Cambridge Preservation Society in 1932 and Kibworth Harcourt Mill where the Society for the Protection of Ancient Monuments (SPAB) took on ownership in 1936. Groups of enthusiasts became involved in securing and restoring these local landmarks that were seen as part of the fabric and history of the local landscape.

Such was their already recognised historical significance, the vast majority of the surviving post mills were formally designated as Listed Buildings. Of the 47 post mills currently extant nearly all are listed, save only for three recently constructed or reconstructed ones (Table 1). Five of these mills are also designated as Scheduled Ancient Monuments and three of these are included amongst the fifteen mills that have now had dendrochronological studies of their timbers (Table 2). Locations of the 47 surviving post mills are largely concentrated in southern and eastern England (see map, Fig. 4). It is not entirely clear why this should be so, since although the area undoubtedly had more mills historically, their distribution extended from Cornwall to Scotland. Perhaps higher winds in these areas made survival less likely, but there are no simple answers to this conundrum.

SCIENTIFIC TIMBER-DATING TECHNIQUES

Dendrochronological dating is often a problem in windmills, which often tend to contain faster-grown

oaks, which are actually stronger (they have a lower proportion of early wood hollow vessels).[16] Elm is sometimes used, which also poses problems for conventional dendrochronological dating.[17]

In windmills, individual timbers often get re-used, so whilst it is possible to identify different phases, of course one cannot guarantee that a re-used timber came from an earlier mill, and not from elsewhere. For example, at Great Chishill Windmill two wall studs and two floor joists in the buck contain many mortises that are irrelevant to their current position and function (Fig. 18) and are clearly pre-used old timbers upcycled during a past rebuild, but where they were previously, we cannot be sure.[18]

In recent years, two other dating methods are being increasingly employed for dating these more problematic timbers, radiocarbon dating and oxygen isotope dating, both discussed previously in *VA*.[19] The radiocarbon improvements with the new IntCal20 calibration curve usually results in tighter date ranges being produced from wiggle-matched sequences, where samples a known number of years apart can be related to the calibration curve. However, there remain some difficult periods, with the quarter bars at Bourn, for example, giving equal probabilities of a date range in the eighteenth and twentieth centuries, along with a small possibility of a date even in the late nineteenth century.[20]

COMBINING DENDROCHRONOLOGY WITH INSIGHTS FROM OTHER EVIDENCE TO BUILD A HISTORY OF EACH MILL

With dendrochronological investigations on several post mills over the last few decades, it has become clear that the concept of 'the oldest post mill' is a challenging one to answer in a simplistic way. Most post mills represent a composite of several centuries of design changes and phases of repairs and rebuilds. We present here a synthesis of various sources of evidence for all of the post mills where we currently have dendrochronological data (see summary in Table 3). For

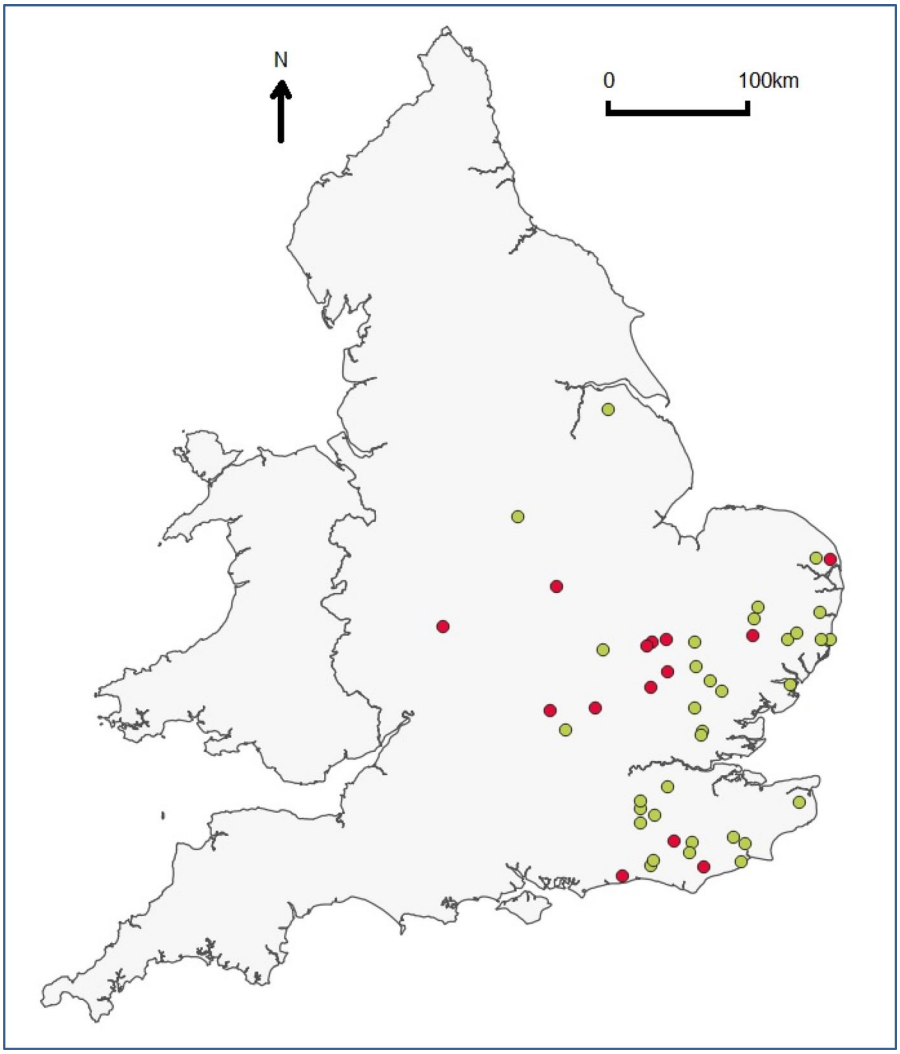

Figure 4. Distribution of surviving post mills in UK (total: 47 mills): With dendro' data ● Without dendro' data ●

each mill we illustrate how these different sorts of evidence combine to help create a collective understanding of the history of each mill.

Although dendrochronological studies have often been undertaken opportunistically when major restoration work was planned or just about to take place, the mills included here are by no means a random sample since the study and repair of these particular mills were already prioritised due to them being thought to be of some antiquity. This group of mills includes the majority of those that are likely to prove to be the oldest post mills amongst those that remain.

BOURN WINDMILL (CAMBRIDGESHIRE)

This mill was recently investigated using ring-width, radiocarbon and oxygen isotope dendrochronology, funded by Historic England.[21] Bourn retains several characteristics of the earliest post mills including a wooden windshaft, a tailpole and yoke for winding, a pitched roof and an exposed or 'open' trestle. The mill body is of comparatively small size, measuring only 9 ft 9 in (3 m) wide and just over 14 ft (4.33 m) in length. It also currently still has two canvas-spread 'common' sails (as opposed to 'spring' sails where angles are mechanically altered). It even has the appearance of a medieval post mill—the roof shape at Bourn (Figs 2 and 5), with its straight rafters, is strikingly similar to the roof shape of a post mill shown, for example, in the Luttrell Psalter which dates back to the fourteenth century (1320–40), and which is believed to have been located not far away, near Ely in Cambridgeshire.[22]

Bourn has long been thought to be one of the oldest surviving mills in the country.[23] This is based partly on a deed of 1653 that refers to an earlier transfer of ownership in 1636, clearly implying that a mill existed here before that date. Dendrochronological evidence now pushes the date back even further. Four out of 21 cores from Bourn returned positive dendrochronology dates. The 14 ft 6 in (4.42 m) long main post (Fig. 5) gives a *terminus post quem* (*tpq*) date of 1515, and it seems likely the tree was felled shortly after this date, which would make it the oldest main post yet dated (Fig. 19), far earlier than the documentary evidence for 1636 suggests. [24]

It is known that Bourn had two mills in the eighteenth century, operated by the same family. It has been assumed that the extant mill was the one that

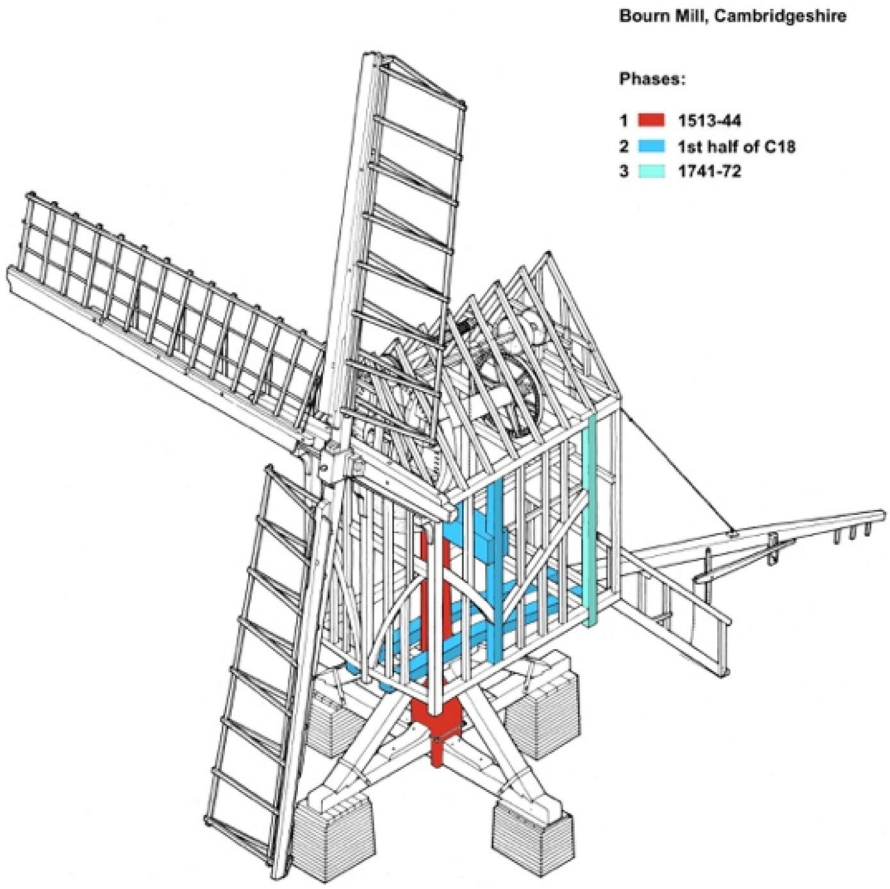

Figure 5. Bourn: Scientifically dated timbers at Bourn Windmill, Cambridgeshire. Based on an original drawing by John Reynolds

Table 1. Surviving post mills in the UK and their current designation status

County (and number of surviving post mills)	Name of Mill/Location	Dated	Ordnance Survey grid reference	Status (historic/ rebuilt/new)	Listed Building designation	Date of designation
Bedfordshire (1)						
	Stevington Mill		SP 99194 52760	Historic	II*	1952
Buckinghamshire (2)						
	Brill Windmill (Nixey's Mill)	Y	SP 65198 14146	Historic	II*	1951
	Pitstone Windmill, Ivinghoe	Y	SP 94510 15677	Historic	II*	1951
Cambridgeshire (5)						
	Bourn Windmill	Y	TL 31189 58005	Historic	I SAM	1962
	Great Chishill Windmill	Y	TL 41321 38843	Historic	II*	1967
	Gransden Windmill	Y	TL 27715 55522	Historic	II* SAM	1983
	Madingley Mill	Y	TL 40795 59513	Historic	II*	1962
	Six Mile Bottom Mill, Burrough Green		TL 58822 58183	Historic	II*	1980
Derbyshire (1)						
	Dale Abbey (Cat and Fiddle Mill)		SK 43793 39778	Historic	I	1952
East Sussex (5)						
	Argos Hill Mill, Mayfield		TQ 57020 28298	Historic	II*	1953
	Cross in Hand (New Mill)		TQ 55793 21755	Historic	II	1952
	Windmill Hill Mill, Herstmonceux	Y	SK 82086 27946	Rebuilt 2004	II*	1952
	Icklesham (Hogg Hill Mill)		TQ 88713 16025	Historic	II	1961
	Nutley Windmill	Y	TQ 45099 29082	Historic	II*	1973
Essex (7)						
	Ashdon (Stevington End Mill)		TL 59522 42537	Historic	II	1967
	Aythorpe Roding Mill		TL 59034 15159	Historic	II*	1967
	Bocking Mill		TL 76307 25967	Historic	I	1951
	Finchingfield (Duck End Mill)		TL 68547 32974	Historic	II	1953
	Ingatestone (Mill Green Mill)		TL 63967 00741	Rebuilt 1959	II*	1952
	Mountnessing Mill		TQ 63099 97967	Historic	II*	1952
	Ramsey Mill		TM 20921 30407	Historic	II*	1952
Greater London (1)						
	Keston Mill		TQ 41545 64028	Historic	I	1955
Hertfordshire (1)						
	Cromer Windmill, Ardeley	Y	TL 30452 28642	Historic	II*	1967
Kent (3)						
	Chillenden Mill, Goodnestone		TR 26899 54238	Rebuilt 2005	II*	1963
	Rolvenden Mill		TQ 83815 31537	Historic	II*	1962
	Stocks Mill, Wittersham		TQ 91304 27305	Historic	II*	1952
Leicestershire (1)						
	Kibworth Harcourt Mill	Y	SP 68875 94404	Historic	II* SAM	1986
Lincolnshire						
	Wrawby Mill		TA 02607 08753	Rebuilt 1961-65	II*	1951
Norfolk (3)						
	Garboldisham Mill		TM 00275 80472	Historic	II*	1958
	South Walsham Mill		TG 379 129	New 1990s onwards	Unlisted	
	Thrigby Post Mill	Y	TG 467 122	Rebuilt 1980s	Unlisted	

(*Continued*)

County (and number of surviving post mills)	Name of Mill/Location	Dated	Ordnance Survey grid reference	Status (historic/ rebuilt/new)	Listed Building designation	Date of designation
Oxfordshire (1)						
	Chinnor Mill		SP 749 010	Rebuilt Q4 20th century	Unlisted	
Suffolk (7)						
	Aldringham cum Thorpe (Thorpeness Mill)		TM 46815 59837	Historic	II	1951
	Drinkstone Post Mill	Y	TL 96418 62202	Historic	I	1954
	Framsden (Webster's Mill)		TM 19181 59753	Historic	II*	1955
	Friston Mill		TM 41131 60114	Historic	II*	1983
	Holton Mill		TM 40226 77444	Historic	II	1953
	Saxtead Green Mill		TM 25336 64426	Rebuilt 1958	II* SAM	1984
	Stanton (Upthorpe Mill)		TL 97133 73299	Historic	II* SAM	1970
Surrey (4)						
	Lowfield Heath Mill, Charlwood		TQ 23491 40723	Rebuilt 1980s	II	1991
	Outwood Mill		TQ 32770 45551	Historic	I	1958
	Reigate Heath Mill		TQ 23435 50036	Historic	II*	1951
	Tadworth Mill		TQ 23630 55396	Historic	II	1983
West Midlands (1)						
	Mill at Avoncroft Museum (Danzey Green Windmill)	Y	SO 95181 68207	Rebuilt 1970s	II	1986
West Sussex (3)						
	Clayton (Jill Mill)		TQ 30366 13368	Historic	II*	1957
	High Salvington Windmill (Durrington Mill)	Y	TQ 12270 06666	Historic	II	1949
	Keymer (Oldland Mill)		TQ 32118 16210	Rebuilt 1990s	II	1957
Total Count (47)						

blew down in 1741, killing miller Richard Bishop,[25] but the dates found for various components, though they may have been recycled, suggest much of the current mill dates before 1741, and point to it having been the other, now lost, mill involved in this terrible accident.[26]

NUTLEY WINDMILL (EAST SUSSEX)

This mill (Figs 6 and 7), located in Ashdown Forest, has been revealed as containing another sixteenth-century main post.[27] The mill's history is complex, there being no firm evidence for a mill at this location before 1836. However, there is some intriguing evidence to suggest that the mill was moved to its present site from Kilndown, Goudhurst, Kent, from where a mill had 'disappeared' between 1710 and 1769.[28]

The main post was found from the dendrochronological analysis to be from a tree with a last measured ring formed in 1529 (see Fig. 19). There is no evidence of sapwood, but it is likely that the heartwood-sapwood boundary was not long after this date, meaning the tree was likely to have been felled in the mid sixteenth century. The front cross-support to the floor was from a tree felled in the period 1738–70, which would match possible rebuilding if it had indeed been brought from Kent in the period highlighted.

PITSTONE WINDMILL, IVINGHOE (BUCKINGHAMSHIRE)

This mill is located between the villages of Ivinghoe and Pitstone in the Chilterns and has often been quoted as the oldest dated post mill in the country. Pitstone is now owned by the National Trust and the sign welcoming visitors makes the bold statement that 'This is believed to be the oldest windmill in the British Isles … '.

The mill body carries a prominent inscribed date on its side wall framing (Fig. 8) which has been variously interpreted as 1627 and 1697. The earliest of these

Table 2. Summary totals of types of designations of post mills

		Unlisted	*3*
Listed Buildings	Listed Building Grade	II	11
		II*	27
		I	6
Total listed			47
Scheduled Ancient Monument (SAM)	of which	SAM	5

Figure 6. Nutley Windmill (East Sussex) in 2020 (photo: Martin Davies)

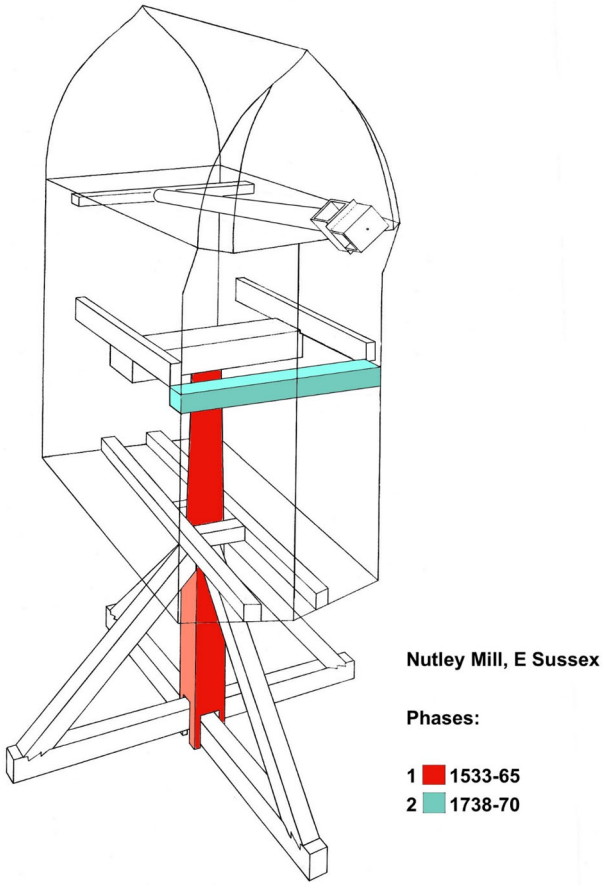

Figure 7. Scientifically dated timbers at Nutley Windmill, East Sussex

dates, if true, would indeed be the oldest carved inscription on an English post mill. However, dendrochronology has now revealed that parts of the mill are considerably older than either of these dates would suggest. Twelve out of a total of 16 cores yielded positive dates (Fig. 10).[29] Unsurprisingly, the earliest dated component is the beautifully moulded sixteenth-century main post which has a *tpq* of 1545 (see Fig. 19).

The four corner posts of the mill body form a coherent group, with felling dates in the 1590s. These provide clear evidence that post mills of this size and design were in existence by the end of the sixteenth century. It is possible that the main post accords with this construction phase. The crown tree was made from an oak felled in spring 1670, indicating a major rebuild during the late seventeenth century.

The cross trees and quarter bars are from trees felled in the period 1824–48. This shows that, as at Bourn and elsewhere, the exposed trestle timbers had decayed to a point where their renewal had become essential. The roundhouse, which carries a datestone of 1895, arrived too late to protect the earlier trestle timbers, and for at least 268 years of its working life Pitstone was an open trestle post mill like Gransden and Bourn.

Figure 8. Inscribed date of 1627 on LH lower side girt at Pitstone Windmill (photo: Martin Davies)

MADINGLEY MILL (CAMBRIDGESHIRE)

Located just north-west of Cambridge, Madingley Mill (Figs 11 and 12) has a fascinating history of alteration, removal and rebuilding. A timber in the right-hand wall of the buck carries the inscribed date of 1785. This mill originally stood in the village of Easton, Huntingdonshire. In 1835 it was moved again a few miles to Ellington and rebuilt in a modernised form with a roundhouse, an automatic fantail and shuttered sails of the type patented by William Cubitt in 1807. Its rebuilt external appearance matched that of Upper Dean post mill, Bedfordshire, which had been altered by the same millwright the previous year.[30] Exactly a century later the mill was dismantled again and reconstructed at Madingley (see Fig. 11), where it was intended as a landscape feature and was not

Figure 9. Pitstone Windmill (Buckinghamshire). Note the full set of four plain (cloth) sails (photo: Martin Davies)

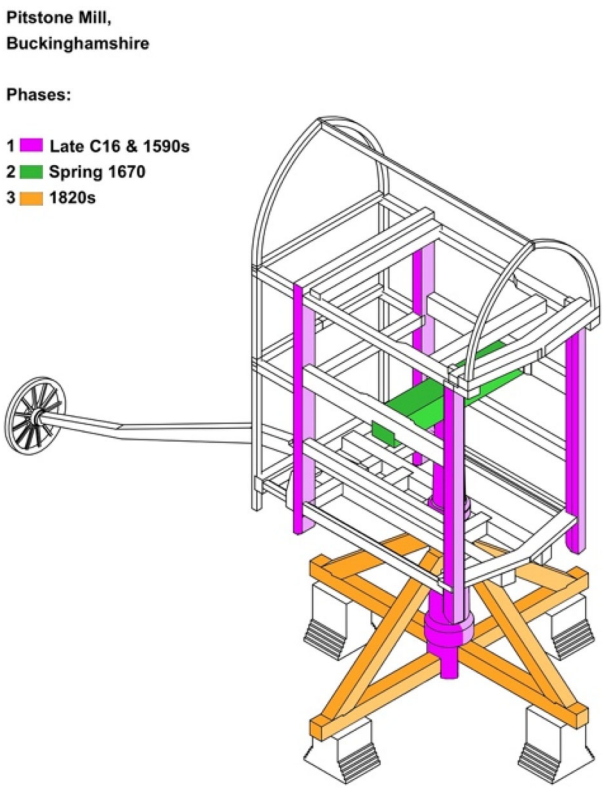

Figure 10. Scientifically dated timbers at Pitstone Windmill, Buckinghamshire. Based on a drawing by John Brandrick

operated. Its appearance was altered to reflect that of a previous different post mill on the site which had collapsed in 1909.

It has the typical 'Midlands' post mill structure with a petticoat to the roof of the roundhouse and a kerb and rollers resting on the top of the roundhouse wall which thus partly take some of the weight of the buck, allowing the whole roof to rotate.

Six of the eight structural timbers sampled returned positive dendrochronological dates (Fig. 12).[31] The oldest dated timber is the crown tree, which was felled between 1568 and 1570 (see Fig. 19). Although potential matches for the main post were discussed, recent reassessment has failed to establish a date. Its appearance suggests the main post has been made from a tree that was managed, perhaps by shredding or pollarding, making dating by conventional dendrochronology impossible.

Other components of the buck have an ancient appearance, but the dendrochronological data shows that the wooden windshaft, the tail beam and both side girts come from timbers felled during the second or third decades of the nineteenth century. One of the quarter bars of the trestle was felled after 1796 so it could also be part of this second phase.

DRINKSTONE POST MILL (SUFFOLK)

The Drinkstone post mill buck is an intriguingly complex structure which was extended at both front and

Figure 11. Madingley Mill in Cambridgeshire. Formerly located at Ellington and before that at Easton, both then in Huntingdonshire (photo: Martin Davies)

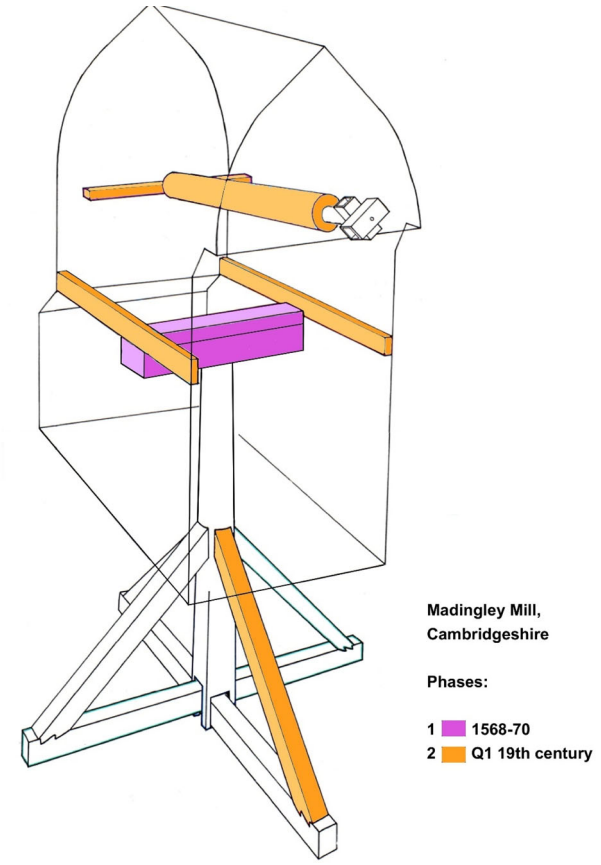

Figure 12. Scientifically dated timbers at Madingley Mill, Cambridgeshire

the rear during its working life, and contains many timbers of different ages.[32] The mill's ancient trestle includes the oldest quarter bar so far recorded in an English post mill.

Like Bourn Windmill, the use of vertical timbers as the principal components of the side wall frames, rather than the ubiquitous horizontal side girts, makes Drinkstone Post Mill highly unusual from a structural standpoint. Only a handful of English post mills are known to have been framed in a similar way. This feature, and the survival of numerous ancient timbers within its buck and trestle, confirms Drinkstone Post Mill's exceptional significance nationally.

A windmill on the site first appears in the documentary record in a land survey of 1616.[33] This evidence post-dates the earliest surviving timbers in the mill which have been identified by dendrochronology. The four original corner posts of the buck are jowled at their upper ends and have a medieval appearance, and are labelled Phase 1 in Figure 13. Their retention from earlier structures is evident as the rear pair have been re-used upside down.

A pair of stout posts in the front wall of the mill appear to have been re-used in their same relative positions when the buck was extended forwards. Dendrochronology shows that these matching timbers were felled between 1543 and 1574. Typologically, the studwork, braces and mid rails in the side wall panels are thought to form one group of timbers.[34] This group appears to have been re-used in a comprehensive reconstruction of the mill in, or shortly after, winter 1586/7, when a new main post was installed. The trestle timbers may well have been renewed at the same time, but although they are stylistically similar to the main post, most have not provided positive dates. Dendrochronology has shown that at least one quarter bar was renewed in 1656–85 (of very similar date to the crowntree, felled 1661/2 and therefore shown in the same colour in Fig. 13).

A prominent inscribed date of 1689 is visible on the vertical post of the right-hand side wall of the buck. At or around this time, the side walls were altered once again, when the typologically similar vertical posts, upper and lower side rails were installed. The crown tree that supports these posts was felled in 1661/2.[35] It is unclear whether this and the dated quarter bar formed part of the *c.* 1689 modifications. Although this may be a logical assumption, they are shown in Figure 13 as separate phases (Phases 4 and 5) since that would be a long time after felling for the main post.

KIBWORTH HARCOURT MILL (LEICESTERSHIRE)

This is the only surviving post mill in the county (Fig. 18). There is a long, well-documented history covering this mill as it belonged to Merton College Oxford throughout its working life. In 1936, ownership was transferred to SPAB. The earliest record in the Merton College archives dates to 1286, with records of new construction in a different position in 1356, repair in 1448 and a rebuild in 1515.[36] Curiously, it is not shown on a 1609 map of the area, but is shown on a 1635 map, in its current location.

The mill body sits low to the ground and is simply framed with no diagonal bracing. Externally, the mill has a 'Midlands' appearance, similar to Madingley Mill and Danzey Green Mill at the Avoncroft Museum, where the roundhouse roof rotates with the buck. However, this 'Midlands' appearance at Kibworth Harcourt Mill is somewhat deceptive, as there is no evidence that the roof petticoat ever hid the usual kerb and rollers fitted between the roof and the top of the roundhouse wall to share the weight of the buck, as exist at the other surviving Midlands post mills. Layers of white paint on the trestle and lower part of the buck, underneath the roundhouse roof, confirm that the mill previously had an open substructure.

When dendrochronology was carried out in 2004,[37] fourteen cores were taken from the main post, the quarter bars, the sheers, sheer spacers and front sill beam, the rear corner posts and two wall studs. The buck timbers and quarter bars were dated to 1773,

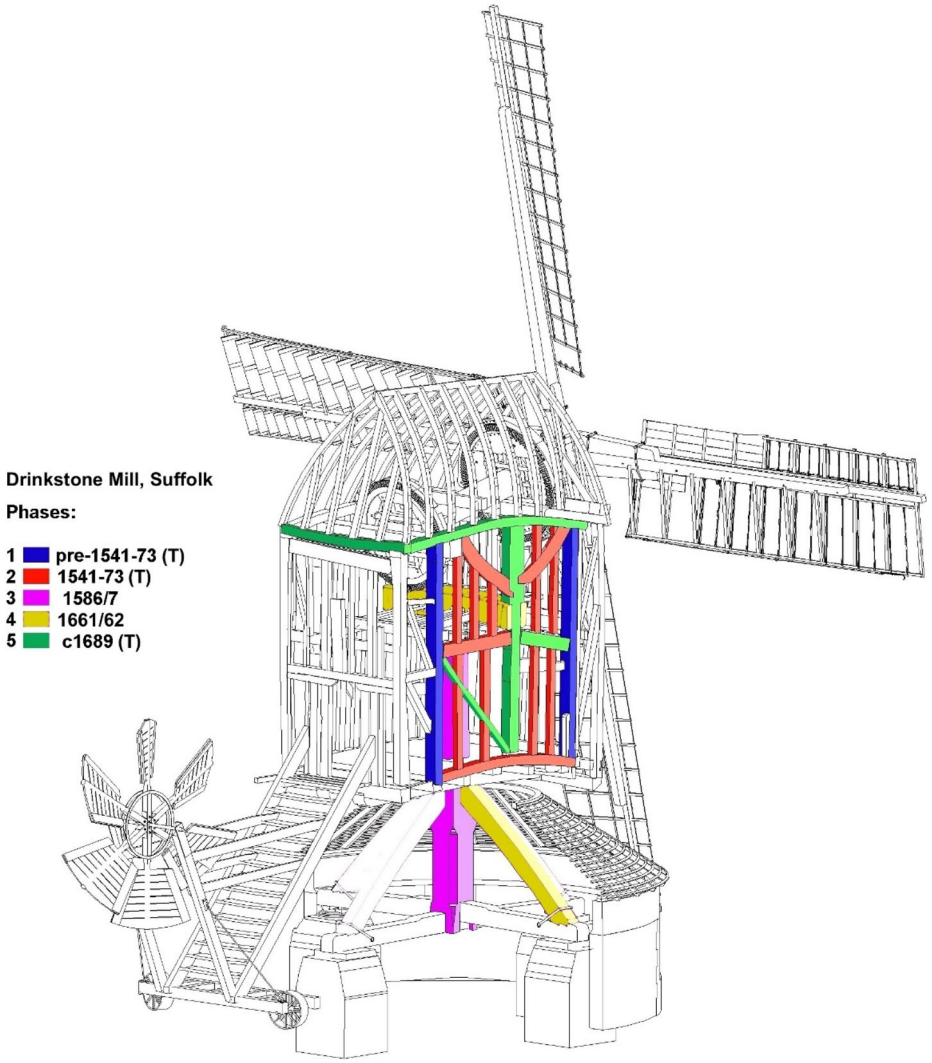

Figure 13. Scientifically and typologically dated timbers at Drinkstone Post Mill, Suffolk. Typologically dated phases are marked (T). Based on a drawing by Vincent Pargeter and John Brandrick

much later than had been expected. This was because the main post carries a carefully executed inscription, 'Daniel Hutchinson, Miller, 1711'. This significantly pre-dates the dendrochronological date of the other structural timbers, suggesting that in the 1773 rebuild the main post was probably re-used from an earlier mill on this site.

The main post was found to be unsuitable for dating in 2004. During more recent dendrochronology studies, an additional thirteen cores have been extracted. These have pushed the felling dates of the bulk of the sampled timbers into early 1774, and the main post has a radiocarbon wiggle-match date which, taking into account likely sapwood numbers, gives a *tpq* range of *1574–1620* (95%) or *1584–1605* (68%).[38]

GRANSDEN WINDMILL (CAMBRIDGESHIRE)

There are records of a windmill on this site in Great Gransden since the early thirteenth century. Throughout its working life it was owned by Rippington Manor. There were two similar post mills in the village during the time of Elizabeth I and we have an intriguing reference to the sale of one of them in 1600, but frustratingly do not yet know which of the two it was.[39] Only the present mill survived to be shown on Thomas Jeffrey's map of Huntingdonshire in 1786.

Gransden Windmill is similar in appearance to Bourn and retains an open trestle, two common sails which would be canvas-covered (and two shuttered sails), and a wooden windshaft (Fig. 3). Its working life ended in 1911, following the death of the miller (William Jabez Webb); his son (Aubrey Lemuel Webb) was later killed in 1918 during the First World War.[40]

The condition of the mill continued to deteriorate over the next 50 years and, despite various attempts to shore it up, it had reached an increasingly precarious state by the 1970s. Although a substantial but vital restoration in 1979–87 resulted in the loss of a number of

its historic timbers, six out of thirteen cores taken from the remainder provided significant dendrochronological dates (Fig. 14).[41]

Inscriptions in the mill include the date of 1674 on a heavily modified timber in the left side wall. The felling date from dendrochronological samples of the main post (1628–60) is slightly earlier than this inscription.

Renewal of the right sheer between 1768 and 1800 suggests a reconstruction of the buck at this date. Extensive repairs may have been necessary soon afterwards, as three timbers in the front, right and left wall panels form a group of timbers that were felled between 1803 and 1832. A fourth phase of extensive repairs is represented by the installation of the wooden windshaft, which has a surprisingly late felling date of 1845–77. Here, as at most other mills that retain wooden windshafts, the exposed forward end of the shaft has been cut off and replaced with a cast iron canister, which is much more resistant to the ravages of the weather.

The Webb family, who were millers and bakers in many local villages in this part of East Anglia,[42] became involved as millers at Gransden in 1848 and remained so until the mill ended its working life in 1911. An inscription shows the initials of Cornelius Webb 1848 on the ancient flour bolter (which itself dates back to at least 1774).

This date ties up well with the dendrochronological evidence as to the age of the wooden windshaft which dated to 1845–77, suggesting that its replacement formed part of a major rebuild of the mill at that time which we know coincided with a change of the tenant millers. The rear extension to the stone floor to accommodate the addition of a second pair of millstones and a tailwheel to drive them were changes that probably also took place at this time.

In contrast, the main post has a dendrochronological date that is some 200 years earlier, almost certainly from the origins of the existing structure, showing a felling date range of 1628–60 (Fig. 19). Oxygen isotope analysis of the crown tree has recently revealed a felling date of 1644/5.[43] This may suggest that an installation of these two major timbers took place together at the same time (either alone would itself require a major rebuild), but it is interesting to note that if this coincided with the crown tree date, it would have taken place in the middle of the English Civil War.

CROMER WINDMILL (HERTFORDSHIRE)

Cromer Windmill is in the parish of Ardeley, Hertfordshire, and may occupy the site of the windmill mentioned in a documentary account of 1222.[44] Archaeological excavation of the prominent mill mound showed it had been artificially constructed in the sixteenth century or later, and originally had a cobbled working surface.[45]

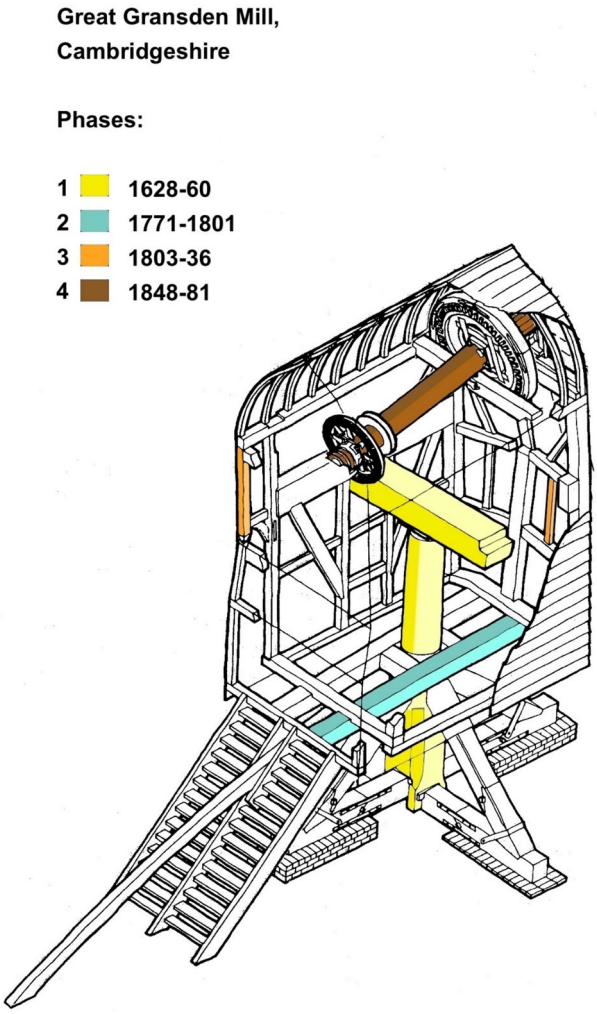

Figure 14. Scientifically dated timbers at Gransden Mill, Cambridgeshire. Based on a drawing by Graham Black

The mill (Fig. 15) is a good example of the 'advanced' design of East Anglian post mill that reached its zenith during the nineteenth century. Its key features include curved roof rafters of elegant ogee profile, a cast iron windshaft, patent shuttered sails, a brick roundhouse and a fantail. The spacious buck, 19 ft 2 in (5.84 m) in length and 11 ft 3 in (3.43 m) wide, incorporates diagonal bracing throughout. Two pairs of millstones are positioned in front of the crown tree, an internal arrangement indicative of a good understanding of post mill framing and balance.

Ian Tyers carried out a dendrochronological survey in 1998, extracting twelve cores of which seven returned positive dates.[46] In spite of the mill's 'modern' appearance, the 18 ft 9 in (5.7 m) long main post was found to have been felled in 1678 or very soon after (Fig. 19). A vertical timber in the rear wall of the buck, felled between 1661 and 1700, is likely to be contemporary with this. It carries the partly

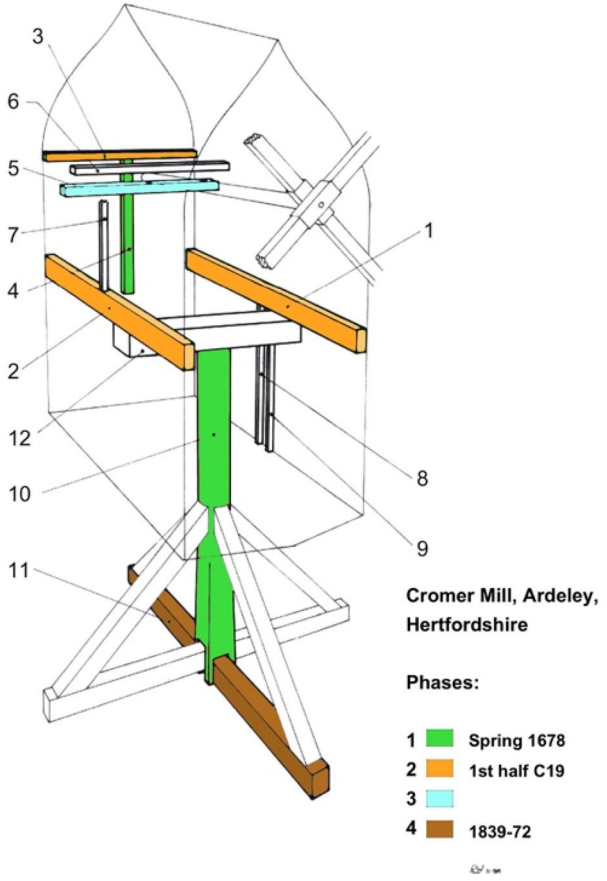

Figure 15. Scientifically dated timbers at Cromer Windmill, Ardeley, Hertfordshire. Sampled timbers are numbered. Based on an original drawing by Robin Webb

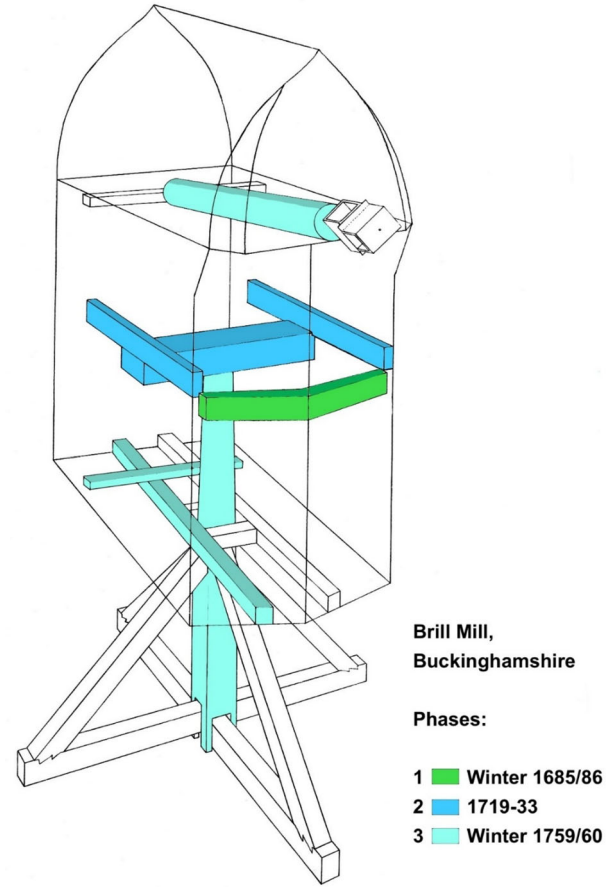

Figure 16. Scientifically dated timbers at Brill Mill, Buckinghamshire

obscured incised date of 1681 and appears to have been re-used in this location.

The mill's present appearance seems likely to be the result of a reconstruction during the first half of the nineteenth century. The full-length side girts have been dated to 1807–39 and 1815–47, and the rear tiebeam, felled after 1831, is likely to be contemporary. As with other sampled post mills, one of the trestle timbers was a late replacement, having been felled between 1839 and 1872. This overlaps with the above group and again could be contemporary.

BRILL WINDMILL (BUCKINGHAMSHIRE)

Several post mills once stood in and around the village of Brill. The survivor, sometimes called Nixey's Mill, contains numerous verifiable inscriptions recording past millers, such as 'W Welford 1848' on one of the lower side girts. Two prominent dates are boldly carved in relief on two of the mill's main timbers. Both of these have been damaged as a result of later internal alterations.

'R C E -68- IC' appears on the inner face of the original rear door lintel. This has long been read as '1668' and the RCE thought to relate to King Charles II (Rex Carolus), but in fact the numbers are missing at either end, so a date in the 1680s is more likely, and IC is now thought to be Isaac Cummings, for whom the mill was built. Although the lintel could not be dated, the inscription corresponds with the dendrochronological dated meal beam in the front wall of the mill body, which was felled in the winter of 1685/6.

A dendrochronology survey was carried out in 2006 and identified three coherent groups of dated timbers from eight out of a total of thirteen cores (Fig. 16). At Brill, there were at least two earlier phases shown by dating other timbers (earlier than the 'soon after 1515' date of the main post at Bourn). A phase of major rebuilding is represented by the crown tree and side girts, all of which were felled between 1719 and 1733. A decoratively carved date '1723' is visible on the rear face of the crown tree. A repositioned floor joist now obscures the last digit of this date.

Another major reconstruction took place shortly after the winter of 1759/60, which is the felling date of a group of four timbers comprising the main post, the right sheer, the rear door threshold and the wooden windshaft. The windshaft contains redundant mortices and slots for gear wheels and cogged rings of a different design to those that currently exist, indicating a major reworking of the internal arrangement sometime

after 1760. Although assessment of the internal machinery is outside the scope of this paper, Brill Windmill has been extensively analysed in print in recent years.[47]

GREAT CHISHILL WINDMILL (CAMBRIDGESHIRE)

Seller's map of Hertfordshire of 1676 records a mill on this site, although it is not shown on Ogilby and Morgan's map of 1678. The mill reappears on Warburton, Bland and Smyth's map (*c.* 1724) and subsequent ones.[48] A depiction of the mill from a map of 1769 shows a hand-winded post mill (manually turned into the wind) with a roundhouse and a rear extension to the buck at mid height which forms a covered porch over the door. The disappearance of the roundhouse in the course of subsequent remodelling is surprising.

In its present form, the buck has a full-width enclosed porch at the rear of the lower floor but no extension above it. The porch appears to be an afterthought because a short, steeper section of tail ladder has been added on top of the existing one. The mill carries patent shuttered sails and a fantail mounted on an unusually elaborate framework above the rear ladder.

An inscribed date of 'IS 1712' appears on a repositioned timber inside the mill. The wall framing of the buck includes several timbers that appear to have been re-used from earlier structures, containing many mortises that are irrelevant to their current position and function (Fig. 17). Two of these timbers have been re-utilised as wall studs and others as joists in the floor of the buck. The timber of one of the wall studs had a felling date within the period 1693–1726.

Two main phases of construction have been identified by dendrochronology. Other than this re-used wall stud, the earliest dated timber is a diagonal brace in the front wall of the buck which was felled between 1699 and 1732. This broadly accords with the 1712 inscription. Two corner posts, the left-hand sheer and the weather beam form a group of timbers with felling dates in the range 1808–47. A precise felling date of winter 1817/18 was attributed to the weather beam. This matches very well with the rebuilding dates quoted in mill literature: Rex Wailes states, 'believed built 1819'.[49] Later nineteenth-century alterations were carried out: a second sampling visit, not recorded in the original dendrochronological report,[50] dated the main post to 1850–82, which accords well with a statement in a local booklet that records that the main post was replaced in 1877 with a tree from Brandon in Suffolk.

DANZEY GREEN POST MILL AT AVONCROFT MUSEUM (WEST MIDLANDS)

Most of this structure displayed at the museum is essentially the Danzey Green Mill, which was originally at Tanworth-in-Arden, Warwickshire. The mill is reputed to have been built about 1830 on the site of an older post mill.[51] After several decades of dereliction, it was dismantled in 1969 and moved a distance of 14 miles to the Avoncroft Museum of Buildings at Stoke Prior, Bromsgrove. The timbers were repaired by the museum's carpenter and in 1970–1 the mill was re-erected and restored to working order.[52]

Figure 17. Two pre-used old timbers that were upcycled during a past rebuild into wall studs in the buck wall at Great Chishill Windmill. Martin Bridge is drilling a dendro sample from one of them, which when analysed showed it was from a tree felled in the period 1693–1726 (photo: Martin Davies)

Like Kibworth Harcourt Mill, Danzey Green Mill is a simply framed Midlands type of post mill with no diagonal bracing. The mill is turned to wind by a tail-pole and there are four common sails mounted on a wooden windshaft. The original main post could not be used in the reconstruction, so a replacement was procured from the remains of a similar mill at Baxterley, Warwickshire. The replacement post is boldly inscribed 'J B 1793'. In 1994 the Nottingham University Tree Ring Laboratory dated the original main post of the Danzey Green mill as having a heartwood-sapwood boundary date of 1754, indicating a felling date range of 1763–95.[53]

HIGH SALVINGTON WINDMILL (WEST SUSSEX)

Known as Durrington Mill during its working life, the post mill at High Salvington has a tarred body above a circular wooden roundhouse. It is similar in form to Nutley Windmill, with two pairs of millstones driven by heavy wooden gear wheels, a pair each of common

Figure 18. Kibworth Harcourt Mill, 2016 (photo: Martin Davies)

and spring sails and a tailpole for winding. Unlike Nutley, the mill retains a wooden windshaft.

In 1600 the miller at Durrington was William Busbridge. As Durrington never had a watermill this is presumed to be the earliest record of a windmill in the parish. A windmill is shown at the site on Budgeon's 1724 map, but a newspaper article in November 1755 records its destruction by fire. In May 1757, Edmund Drewitt took out fire insurance for a timber-built windmill in 'Derrington', an event which is assumed to record the construction of the present mill a year or so previously.[54]

In a dendrochronological survey carried out in 2013, High Salvington mill yielded two positive dates.[55] One of the beams supporting the rear pair of millstones had a last measured ring from 1769, but with eleven complete sapwood rings unmeasured the felling date is calculated to be *c.* 1780. This is slightly too late to fit with the inscribed date of 1774 on the rear face of the original crown tree. A core from the wooden windshaft had a heartwood/sapwood boundary of 1771, indicating a felling date of 1780–1812.

THRIGBY POST MILL (NORFOLK)

Robert Woolmer, the owner of Thrigby Hall, had Thrigby Post Mill constructed in the early 1790s to grind flour from the wheat grown on his estate. It is shown on Faden's map of 1797 and also on Bryant's map of 1826. Dendrochronology samples were taken from the remaining lower section of the main post in the early 1980s which revealed a felling date for this tree of late 1790, appearing to corroborate the historical evidence.[56]

The mill was worked by a succession of tenant millers for just over 100 years until 1889, and in 1892 William Fowler and William Golden of Stokesby dismantled the buck and cut the main post off above the roundhouse and sealed it. Carved on the lower part of this original main post is an inscription 'J. N. TRETT OCT 4TH 90'. Intriguingly, this main post inscription was made a year after the mill stopped working and just two years before the upper part of it was demolished.

WINDMILL HILL MILL, HERSTMONCEUX (EAST SUSSEX)

The largest post mill in Sussex and one of the largest post mills in England, approaching 50 ft (15.25 m) in height, this impressive post mill stands at Windmill Hill near Herstmonceux, East Sussex. It has a distinctive appearance, being clad in sheet metal, with an unusual double-roofed roundhouse. In spite of its size, the mill was turned with a tailpole throughout its wind-powered working life, which ended *c.* 1893. After more than a century of dereliction, the mill body was dismantled and rebuilt between 2003 and 2005.

The Windmill Hill place name first appears in early sixteenth-century documents. Yeakell and Gardner's map of 1783 shows a windmill near Herstmonceux church which was advertised for sale in November 1798 but seems to have disappeared soon afterwards. The existing mill is described as 'newly erected' in a sale notice of August 1819.

During sampling in 2005, eleven cores were extracted from the trestle and mill body timbers.[57] Six of these returned felling date ranges between 1797 and 1814. The weather beam and main post were felled in winter 1813/14 while the upper cross tree of the trestle was felled the previous winter. This evidence points to a single phase of construction, although numerous other timbers that could not be dated have an earlier appearance, suggesting that the early nineteenth-century construction may have incorporated some second-hand material.

The dendrochronological studies showed that all the dated timbers (including the main post which was contemporaneous with the major components of the buck) represent the historically known phase of building in 1814, but other timbers bearing scribed marks were recognised as likely to be older, although they failed to date.

Table 3. Post mills where dendrochronological dating investigations have been conducted – in earliest mill date order

Name of Mill/ Location	Main post and other timbers with the oldest dates (if older than MP)	Dates of measured sequence	Sapwood	Felling date range of main post	Felling date range of oldest timber (if not main post)	Dendro method (RW = ring width; O = O^2 isotope)	Reference source
Bourn Windmill	Main post	1402–1503$_D$	–	after 1515		RW	Bridge et al. 2022a
Nutley Windmill	Main post	1410–1529$_D$	5	1533–1565		RW	Bridge 2002
Pitstone Windmill	Main post	1410–1536$_D$	–	after 1545		RW	Miles et al. 2004
Madingley Mill	Main post	–	–	Undated		RW	Carter et al. 1996
	Crown tree	1351–1567$_D$	26(+1NM?C)		1568–1570	RW	Carter et al. 1996
Drinkstone Post Mill	Main post	1464–1586$_D$	21C	Winter 1586/87		RW	Bridge 2001
Kibworth Harcourt Mill	Main post		–	*after cal AD 1574-1620*		O	Bridge et al. 2022b
	All others	1582–1773	Several C		1773/74	RW	Bridge et al. 2022b
Gransden Windmill	Main post	1496–1619$_D$	?h/s	1628-1660		RW	Bridge et al. 2022c
	Crown tree	1555–1644$_I$			Winter 1644/45$_I$	O	Bridge et al. 2022c
Cromer Windmill	Main post	1568–1678$_D$	14 ?C	?1678		RW	Tyers 1998
	Rear upright	1555–1666$_D$	4		1661–1700	RW	Tyers 1998
Brill Windmill	Main post	1615–1746$_D$	7	1748–1780		RW	Miles et al. 2007
	Meal beam	1585–1685$_D$	23C		Winter 1685/86	RW	Miles et al. 2007
Great Chishill Windmill	Main post	1755–1849$_D$	12	1850–78		RW	Bridge 2015
	Stud	1628–81$_D$	h/s		1693–1726	RW	Bridge 2015
Danzey Green Mill at Avoncroft Museum	Main post	1675–1754$_D$	h/s	1769–1804		RW	Howard 1994
High Salvington Windmill	Main post	Not sampled		Unknown		RW	Moir 2013
	Hurst beam	1769 $_D$	(+11NMC)		1780	RW	Moir 2013
Thrigby Post Mill	Main post	1692–1790$_D$	14C	Late 1790		RW	Fletcher 1984
Windmill Hill Mill, Herstmonceux	Main post	1711–1813$_D$	21C	Winter 1813/14		RW	Bridge 2005
	Cross tree	1754–1812$_D$	14C		Winter 1812/13	RW	Bridge 2005
Stocks Mill, Wittersham	Main post	Undated			undated	RW	Arnold et al. 2003

Sapwood key: h/s = heartwood-sapwood boundary; NM = not measured; C = complete sapwood. Dates with subscript $_D$ indicate ring width derived date; subscript $_I$ indicates oxygen isotope derived date.

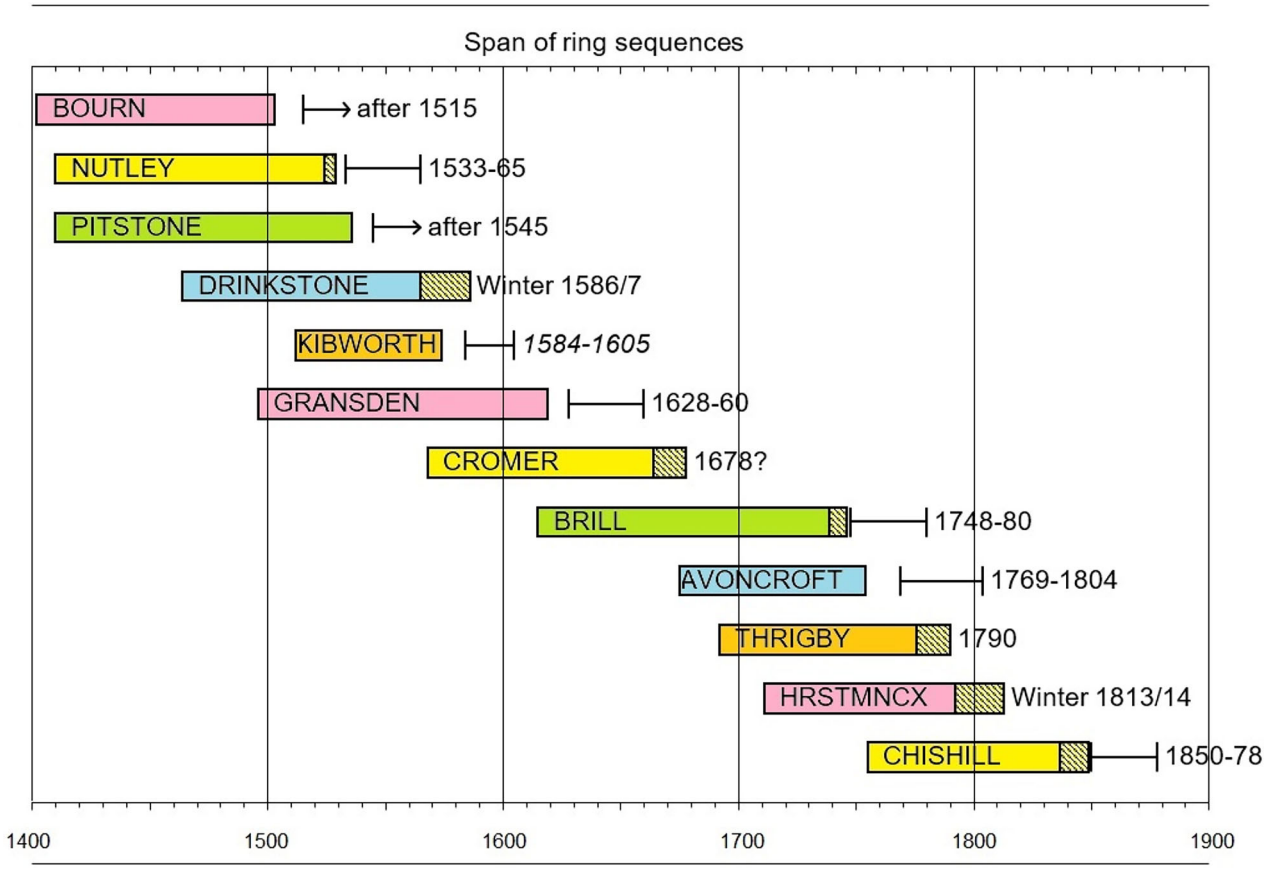

Figure 19. Dendro samples from main posts of some English post mills: span of ring sequences and estimated felling date ranges. This figure shows the span of the ring-width sequences of main posts from various post mills in England. The coloured section of bar represents heartwood rings, hatched sections represent sapwood rings, and actual or estimated felling dates/date ranges are also shown. Windmill Hill Mill is shown as HRSTMNCX

STOCKS MILL, WITTERSHAM (KENT)

This mill stands on the Kent side of the county boundary with East Sussex. The mill shares several design characteristics with other post mills located south of the River Thames.

A prominent carved date of 1781 on the upper part of the main post is thought to relate to the mill's construction. It may have arrived too late to appear on Hasted's maps of 1778 to 1801. Insurance documents of 1792 confirm the mill's existence then.[58]

A dendrochronology survey carried out in 2003 extracted eleven cores from the mill body and trestle but yielded no positive results, with no timbers dated.[59] Whilst Stocks Mill Wittersham is part of the group of fifteen post mills that have had dendrochronological analysis done to date, it is the only one where this analysis has not so far produced any positive dates.

TIMBER SURVIVAL

THE MAIN POST

One of the main conclusions to come from the dendrochronological investigations of the numerous post mills that have been carried out so far is that most mills appear to contain timbers from different historical rebuilding phases, but with the main posts often being the oldest component. This large post needs to be a very substantial timber since it has to support the great weight and movement of the buck, including the sails and millstones, but also has to be of sufficient width to incorporate four deep mortices at the same height, these taking the quarter bars that both support it and relay the weight into the structure of the trestle.

Rackham declared that the post supporting the local mill was the one timber that many local woods were unlikely to be able to produce. He cited the documentation for work carried out at Gamlingay (Cambridgeshire) in the thirteenth and fourteenth centuries and showed just how much effort and cost was involved in obtaining and installing these outsized timbers.[60] He suggested they came mostly from parks and forests, and were often transported long distances.

Being such valuable timbers and difficult to obtain, it is of no surprise that many appear to have been reused when a mill was rebuilt, or underwent a major redesign. The position of the main post at the centre of the structure ensured that it was well protected

from all but the most severe storm damage. Even in the event of a mill's total destruction, the main post was often likely to emerge unscathed and be capable of re-use. This may partly help explain why in many cases it represents the earliest timber surviving in the mill.

The main posts from twelve out of the fifteen mills in this study returned positive dates (Fig. 19). For the earliest of these, at Bourn Mill, the tree began growing in 1402 and was felled sometime shortly after 1515. Physically, it is slightly shorter than the standard length of main posts in England, the majority of which are between 16 ft 6 in and 19 ft (5–5.8 m) in height.

Nutley and Pitstone windmills retain almost equally ancient main posts, felled during the mid sixteenth century. The next oldest post is that of Drinkstone Post Mill, felled in winter 1586/7. The date of the Kibworth Harcourt main post falls between that for Drinkstone and Gransden, despite the inscribed 'Daniel Hutchinson Miller 1711' date. The post of Cromer windmill was felled in or shortly after 1678. The Danzey Green Mill main post has a heartwood-sapwood boundary date of 1754. The original main post at Thrigby Mill was felled in late 1790. Brill Windmill's main post matches other timbers in the buck felled in winter 1759–60. Windmill Hill Mill, Herstmonceux, has the tallest main post in England at 22 ft 9 in (6.93 m) which was cut in 1813/14. The youngest main post sampled is that of Great Chishill Windmill which is recorded as having been replaced as late as 1877.

The age of the main post is significant because, in many cases, it reflects one of the earliest phases of a mill's construction as represented by the timbers currently remaining in the mill (there may have been still earlier phases of course, of which no timbers now survive). However, at Drinkstone Post Mill, which is worthy of a detailed study in its own right, and Brill Windmill there were at least two earlier phases of construction prior to the current main post being installed.

The main post at Windmill Hill, Herstmonceux is contemporary with other dated timbers from the trestle and the mill body, strongly indicating a single phase of construction. As the mill was built on a new site during the last century of post mill building, it is unsurprising that no prior or later reconstruction occurred here.

OTHER TIMBERS

A sixteenth-century crown tree survives at Madingley Mill and seventeenth-century examples include those at Drinkstone, Pitstone and Gransden. Crown trees are usually made of oak, although sometimes are of elm (e.g. at both Great Chishill and Bourn). Any replacement of this timber would result in a major rebuild, since it is the structural component to which the rest of the buck is attached. Rebuilds of windmills frequently incorporate other timbers that have apparently been re-used from previous mills on the same site, such as some of the wall studs and floor joists at Great Chishill.

RELOCATION OF MILLS

From the group of post mills studied in this paper, we have seen examples of whole mills being moved from one location to another (e.g. Madingley from Huntingdonshire to Cambridgeshire; Nutley—thought to have been moved from Kent to Sussex). Knowledge of such moves is obviously crucial to understanding the history of a mill and the timbers it contains. Post mills were often considered portable structures, and could be sold and moved at the whim of the owner. We must therefore be cautious in assuming that surviving ancient post mills have spent their whole life at the site on which they currently stand. In cases such as Drinkstone Mill, surviving timbers pre-date the first documentary record of a mill on the site by a considerable margin.

BALANCING DIFFERENT SOURCES OF EVIDENCE

With virtually all the old mills studied to date proving to be composites of many rebuilds, the idea of asking which post mill is the oldest is perhaps best reformulated. The question is better expressed as 'For which mill can we show the longest historic continuity of at least some components of the existing structure?' Combining the dendrochronology with historical documentary evidence of prolonged occupation of the same site by a mill, inscription evidence and typology of the mill structure, we can come to a view as to which individual mills and group of mills give us the best insights into the earliest history of post mills and how they developed over time.

It is clear that scientific dating using tree ring width dendrochronology and other more recent methods such as oxygen-isotope analysis and wiggle-match radiocarbon dating can yield very useful precise dates for the felling of certain timbers. In the context of windmills, this can sometimes shed new light on the history of a particular mill in ways that would be impossible by any other means and help answer what would otherwise be intractable questions.

However, it can also help raise completely new questions, illuminating stages in the history of a structure that were previously unknown or unsuspected. Answering these questions may then require other sorts of research through historical or technological studies, since it is clear that no single source of evidence can possibly provide all the answers.

For example, a dated inscription on a timber linked to the name of a miller, such as 'Daniel Hutchinson –

Miller 1711' on the main post at Kibworth Harcourt Mill, may open a small window onto the past. The scientific dating, however, shows that the post is much older, but it cannot explain why all the other main structural timbers in that mill have dendrochronological dates that are all much younger than this or what event immediately prior to 1773/4 apparently necessitated a major rebuild of virtually the whole mill at that time. Equally, only documentary research can shed light on who Daniel Hutchinson was or what had happened in 1711 to encourage him to carve his name on the main post at that time.

If we are to build a better understanding of the history of post mills as part of our rural technological and cultural heritage, we need to find ways of combining these various sorts of evidence more effectively so that we can write a more complete story of the past to help us better understand the present.

GENERAL CONCLUSIONS

Fourteen case studies have highlighted that tree ring studies can often provide a very useful insight into the history of individual mills. Only one mill investigated by dendrochronology has so far failed to reveal any dated components.

The notable finding from most of the cases presented has been that the main post has usually proved to be older than many other timbers present and perhaps represents the remnants of a much older mill that has undergone one or more rebuilds. Other forms of evidence, for example from carved dates and documentary sources, have sometimes been backed up directly by the scientific dating. In others, whilst supporting evidence of corroboration has been absent or limited, previously unrecognised phases of repair and renovation have sometimes been discovered which may now stimulate further in-depth historical research.

PRIORITIES FOR FURTHER STUDIES

Most of the studies have used conventional tree-ring width dendrochronology, but more recently oxygen isotope dendrochronology and improvements in wiggle-matching radiocarbon dating have given further insights into dating, and these will open up the possibilities for further mill dating in the future. For example, at Windmill Hill, Herstmonceux there are what appear to be certain older timbers (assumed from scribed carpenter's marks) that are so far undated and these could be looked at again by new techniques. At Madingley the main post is currently undated but a core from it already exists, and this could be investigated by, for example, oxygen isotope methods.

This paper shows there is still much to be clarified on the history of the surviving post mills, despite much careful dendrochronology and other research work. It is emphasised that, for any mill, data from several sources is desirable, with documentary evidence supporting and helping explain the dendrochronology data where possible. It is hoped that the new methods of timber dating, such as the oxygen isotope method, will help advance post mill dating even further.

Another aim of this overview was that it might stimulate additional investigations into the other remaining post mills and to following up on unanswered questions from those investigated so far. By way of example, such further scientific timber dating studies might include:

- studies of the development of the surviving gearing and other machinery of early post mills such as Madingley, Gransden and Drinkstone;
- other surviving mills reputed to be of ancient origin e.g., Outwood Mill, Surrey, Holton Mill, Suffolk, etc.;
- those post mills containing particularly interesting structural features, e.g. Six Mile Bottom Mill, Cambridgeshire;
- surviving fragments of early mills that are no longer standing, e.g. the excavated base of a main post from a buried trestle at Polegate, Sussex.

Perhaps it will also encourage an extension of dendrochronological interest into the history and development of other types of mills such as smock mills and tower mills. Although not discussed in this article, these smock mills and tower mills were often built to replace earlier post mills and were frequently erected on the same site. They probably often included timbers recycled from the old post mill that they supplanted, although none of these mills have yet been dendrochronologically dated.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

NOTES

1. Moore, *Windmills: A New History*, 16–17.
2. Ibid., 17.
3. See Dolman, *Suffolk Windmills*, 3: Holt, *The Mills of Mediaeval England*, 140–3.
4. Freese, *Windmills and Millwrighting*, 144.
5. Pearce, "Traditional Windmill Sails," 1.
6. Jarvis, "Stability in Windmills," 61.
7. Apling, *Norfolk Corn and Other Industrial Windmills*, 7.
8. Jarvis, "Stability in Windmills," 30.
9. Watts, *The Archaeology of Mills and Milling*, 103.
10. Moore, *Windmills: A New History*, 20.
11. Peter Dolman, pers. comm., 1999.
12. Barnard, "Suffolk's Vanished Post Mills," 8.

13. Farries, *Essex Windmills Millers & Millwrights*, Vol. 1.
14. Apling, *Norfolk Corn and Other Industrial Windmills*.
15. Dolman, *Lincolnshire Windmills*, 3.
16. Dating methodologies are discussed in Bridge, "The Science of Dating and Vernacular Buildings."
17. See Bridge, "Elm Dendrochronology."
18. Bridge, *Little (Great) Chishill Windmill*.
19. See Bridge, "The Science of Dating and Vernacular Buildings," and Miles et al., "Stable Isotope Dating."
20. Bridge et al., *Bourn Mill, Caxton End, Bourn, Cambridgeshire*.
21. Ibid.
22. British Library MS 42130 an image of the windmill may be found at (www.heritagelincolnshire.org/blogs/lincolnshires-first-windmill-by-jim-snee).
23. See Wailes, *The English Windmill*, 151: Ward, "Report on the History of Bourn Mill."
24. Peter Filby, pers. comm.
25. Ward, "Report on the History of Bourn Mill."
26. Ibid.
27. Bridge, "Tree Ring Dates," *VA* 34, 95.
28. Information from Wright and Gregory in an undated short guide to the mill.
29. Miles et al., "Tree-ring Dates," *VA* 35, 97.
30. Dolman, correspondence, 1997.
31. Carter et al., "Madingley Composite Mill (Red Mill)."
32. Bridge, *Tree-ring Analysis of Timbers from the Post Mill, Drinkstone, Suffolk*.
33. Paine, C. 2002, unpublished notes on Drinkstone Mills *c.* 1616–*c.* 1938.
34. Alston, "Drinkstone Post Mill."
35. This is new information, as yet unpublished, resulting from a reappraisal of data (Martin Bridge).
36. Moon, *The Windmills of Leicestershire and Rutland.*
37. Arnold et al*., Tree-ring analysis of timbers from Kibworth Harcourt Post Mill, Kibworth Harcourt, Leicestershire*.
38. Bridge et al., *Kibworth Harcourt Mill.*
39. Turner, *Calendar of Feet of Fines*, 220.
40. Hardick, "Gransden Windmill."
41. Bridge, *Great Gransden Windmill.*
42. Valentine, *The Webb Family*.
43. Bridge et al., *Great Gransden Windmill.*
44. Moore, *Windmills: A New History*.
45. https://new.millsarchive.org/mills/index/?action=show&which=2310.
46. Tyers, 'Tree-ring Dates," *VA* 30, 122.
47. Bonwick, *Brill Windmill, Buckinghamshire.*
48. Farries, *Essex Windmills Millers & Millwrights*, Vol. 3, 77–9.
49. Wailes, "The Windmills of Cambridgeshire," 99.
50. Bridge, *Little (Great) Chishill Windmill.*
51. Seaby and Smith, *Windmills in Warwickshire*, 22.
52. Brown, *Windmills of England*, 184–5.
53. Howard et al., "Tree-ring Dates," *VA* 25, 36.
54. Casebow, *High Salvington.*
55. Moir, "Tree-ring Dates," *VA* 44, 90.
56. Fletcher, "Tree-ring Dates," *VA* 15, 69.
57. Bridge, *Tree-ring Analysis of Timbers from the Post Mill, Windmill Lane, Windmill Hill.*
58. Brown, *Windmills of England*, 114.
59. Arnold et al., *Tree-ring Analysis of Timbers from Stocks Mill, Wittersham, Kent.*
60. Rackham, *Ancient Woodland,* 152–3.

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