NEW ZEALAND ARCHAEOLOGICAL ASSOCIATION

ARCHAEOLOGY IN NEW ZEALAND

IDENTIFYING TOOL MARKS ON WOOD SURFACES

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New Zealand has a relatively short and well documented colonial history and it is usefully coincident with well-recorded industrial changes throughout the nineteenth century. Evidence of those technological advances can be found imprinted on all man-made artefacts from that period. Developments in manufacturing process can be used as a timeframe measure. Complex objects, such as buildings, offer a huge array and combination of materials to be assessed and collectively compared. A surprisingly large amount of information can be recovered with careful observation and skilled analysis of seemingly unremarkable artefacts, including timber.

Wood-working initially entails the reduction of timber, with each tool leaving its own peculiar signature. Their marks can give great insight into the period when the wood was shaped to size, the availability of materials, intended purpose and can even provide information about the skill of the craftsman.

Broadly speaking tools fall into two main categories:

1. Those used for measuring and marking such as rules, gauges, squares and bevels.
2. Cutting tools, such as saws, chisels, drills, augers, scrapers and planes.
3. Hammers, mallets and screw-drivers also, I suppose.

This board removed from an old house is an excellent example (Figures 1 and 2). Without any prior knowledge we can observe a significant amount.

The species

It is kahikatea, clearly apparent because of the partially photo-oxidised whitish/grey/brown colour (light woods darken with time; Kaila n.d.: 333-336). Kahikatea has very white sap-wood comprising the greater part of the log and has a yellow heart-wood when first milled. It is a species common throughout

New Zealand (except Stewart Island) in low-lying wet and semi-swamp areas (Cockayne and Turner 1967: 155, 165).

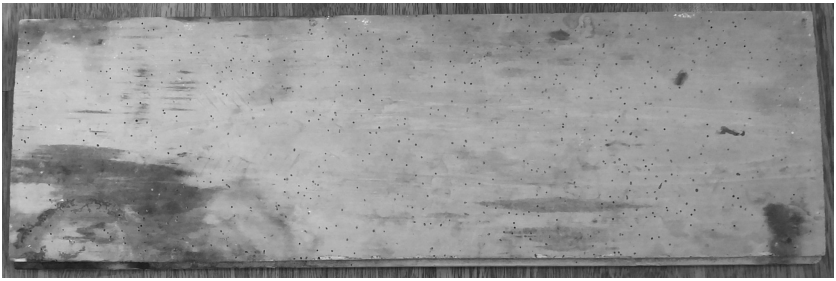

Figure 1. Top side of the kahikatea board.

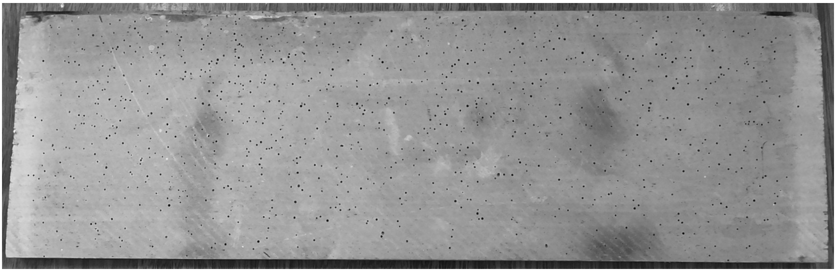

Figure 2. Under side of the kahikatea board.

We should note that this piece of kahikatea is heavily infected with wood worm. This is typical of the sapwood. The first European settlers did not understand the propensity of 'white pine' to fungal decay and borer. This would signal an early use of this timber and obviously a specific region where it was commonly found. It is evident that this board was eaten and tunnelled by woodworm sometime after it was prepared to its final shape. The crisp, sharp edges of the beetle entry/exit points indicate subsequent infestation. Similarly the 'dry' surface is original, as the removal of paint or varnish would have damaged those holes or at least left some residue.

There are lighter strips to the rough sawn face where the wood has been protected from the light. It is clear that this is the underside of the board which lay flat. There are no nails or redundant holes so this board merely rested on supporting rails (Figure 2). The other side is darker and contaminated with dust and signs of use (Figure 3). It does not, however, exhibit 'checking' or fissures caused by excessive exposure to sun and rain nor the silver grey discolouration of metallic oxides and water. It has been well protected in an inside environment.

Figure 3. Contamination to the planed top surface of the kahikatea board and cupping towards the underside.

Regular slightly arced impressions particularly to the underside (Figure 2) show that this board was initially cut on a large circular machine saw. The size of the blade can be calculated by finding the centre of the arc and scribing a complete circle. In this case the blade was 72 inches or 6 feet. The underside, intended to be unseen, has been left rough sawn while the upper surface has been planed or dressed. We also can see that this 1 inch thick board was cross-cut from the tree (across the radius from an area of sapwood) and that the underside was on the outside of the log as the less dense more recent growth wood has shrunk more and cupped away from the denser heartwood (Figures 3 and 4).

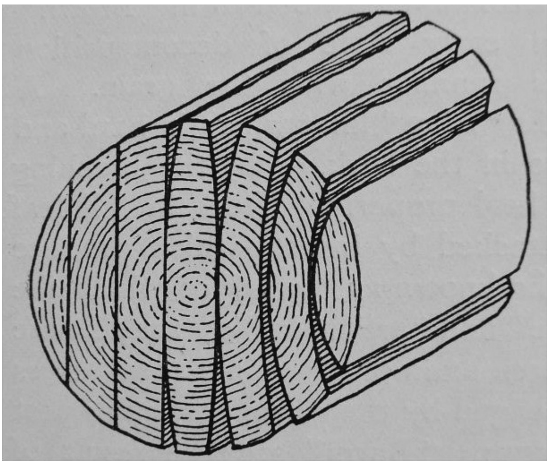

Figure 4. Distortion patterns for quarter and cross-cut timber.

The annual growth rings in this example are not discernible without smoothing the rough end surface fibres. Such a process would be invasive and irreversible, but certainly would be revealing. We could then confirm the exact position where this plank was cut within the log. Furthermore, the variable distances and thicknesses of the annual growth rings will reflect the climatic conditions as the tree was growing. All trees of any species growing in that locality would exhibit similar patterns; that is, wider rings in good seasons and narrower when the tree was less able to take up nutrients in colder or drier summer periods. Moreover, the proportion of minerals taken up by the tree can be determined and compared to regional soil types to determine a probable origin of the analysed board.

Grain patterns as viewed down the side of a long board would offer some chance to determine which way up the board was in the growing tree. In a small tree a taper may be apparent, while knots and flames will occur near branches. Compression ripples occur where the weight of the tree has crushed the grain causing it to concertina (Figure 5). When cut down its length the wood colour appears as a series of light and dark (usually) horizontal stripes. These will be extremely evident if badly planed with bands of 'break-out' or tearing. Compression occurs beneath a heavy bough, intensifying towards the new growth timber on the outside of the tree as the limb gains weight. A broader disturbance in grain direction occurs at the tree base, where the weight load is most severe and the root system radiates away from the largely parallel trunk.

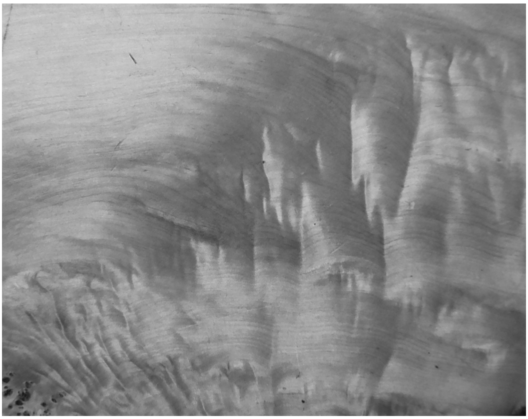

Figure 5. Compression grain in tōtara.

Hand tools

The kerf marks (grooves or notches made when cutting with a saw) to both sawn ends show irregular teeth impressions consistent with short rapid hand strokes. The chip break-outs to the under-side shows that the carpenter used a hand saw to cut the board from the opposite side (or what was to became the top) as the forward-pointing teeth pushed the wood fibres downward, fracturing off the lower unsupported surface (Figure 6).

Figure 6. Break-outs can be seen on the underside of the boad, as well as cupping and a light band of reduced photo-oxidation.

A detailed inspection of this particular board's top face reveals that the craftsman has used a scrub or Bismark plane with a narrow deeply set curved blade (say 40-45 mm). Evidence for this can be seen in the short, slightly choppy texture created of ridges and hollows. Those diagonal marks have then been over planed with a much flatter wider bladed coffin or smoothing plane. It can also be seen that there was a small knick out of the latter plane which printed long fine raised lines parallel to the grain direction (Figures 7 and 8).

Long tear grooves in the upper surface indicate the wood was hand planed soon after milling when the wood was still green or wet (Figure 9). This is caused by the plane blade failing to slice a thin curled shaving since the wet timber was not dry or brittle enough to break forward. Smoothing plane blades usually have a capping iron (or chip breaker), which is designed to massively thicken the blade just behind the cutting edge (Figure 8). This will ensure the shaving is bent steeply away from the blade tip and force the wood to continually break away. Kahikatea can be quite temperamental to work and very stringy when wet and we can still see all of that trouble experienced by the carpenter as he prepared the surface more than 150 years ago.

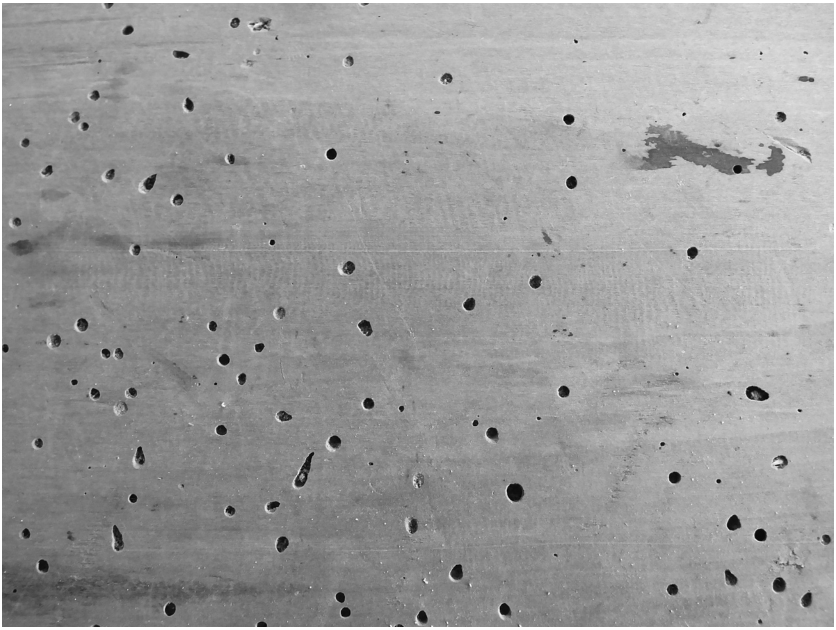

Figure 7. Fine chatter marks indicate a deep set plane blade, maybe with no capping iron where the shavings are breaking forward and not being cut.

There are repeated ‘breakouts’ caused by the plane blade being set too deep. This produced a shaving far too thick to curl evenly and instead broke haphazardly (Figure 9). Furthermore, the wood fibres were being planed obliquely into their ends and not from behind, much like stroking a cat from its tail to the head. The blade edge has cut down the grain and not sliced (from behind), thereby forcing the shaving to break well down below the surface. This is all evidence for rapid workmanship well before the timber had been allowed to season.

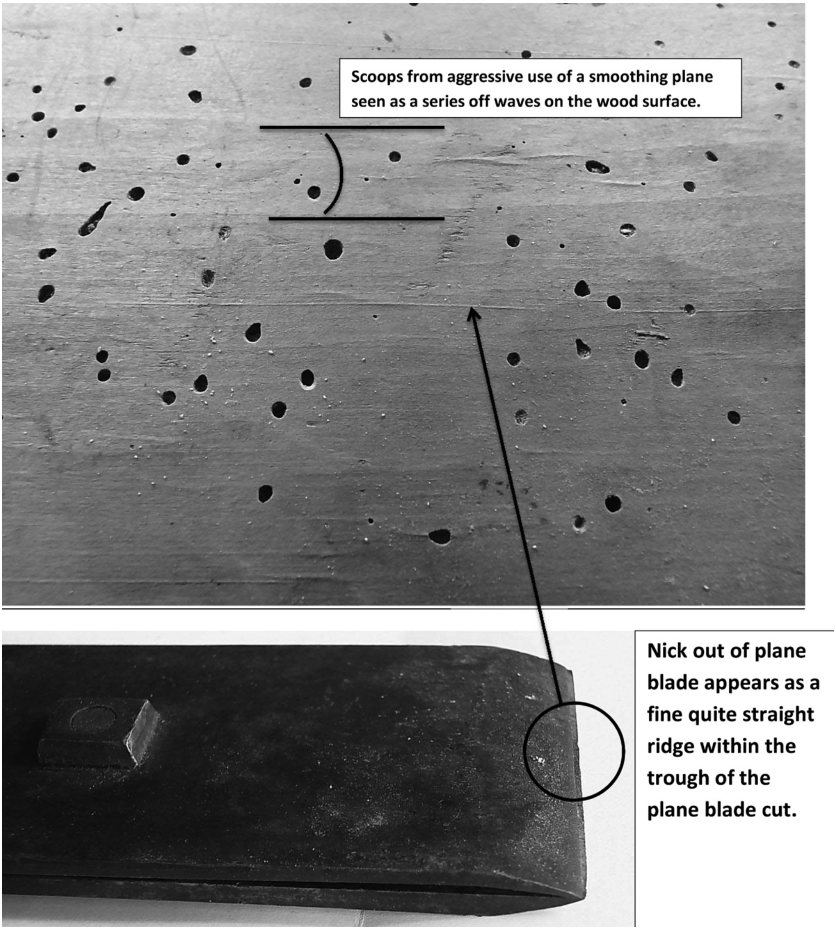

Figure 8. Smoothing plans marks evident as slight waves on the timber surface. Nicks in the blade create thin ridged lines.

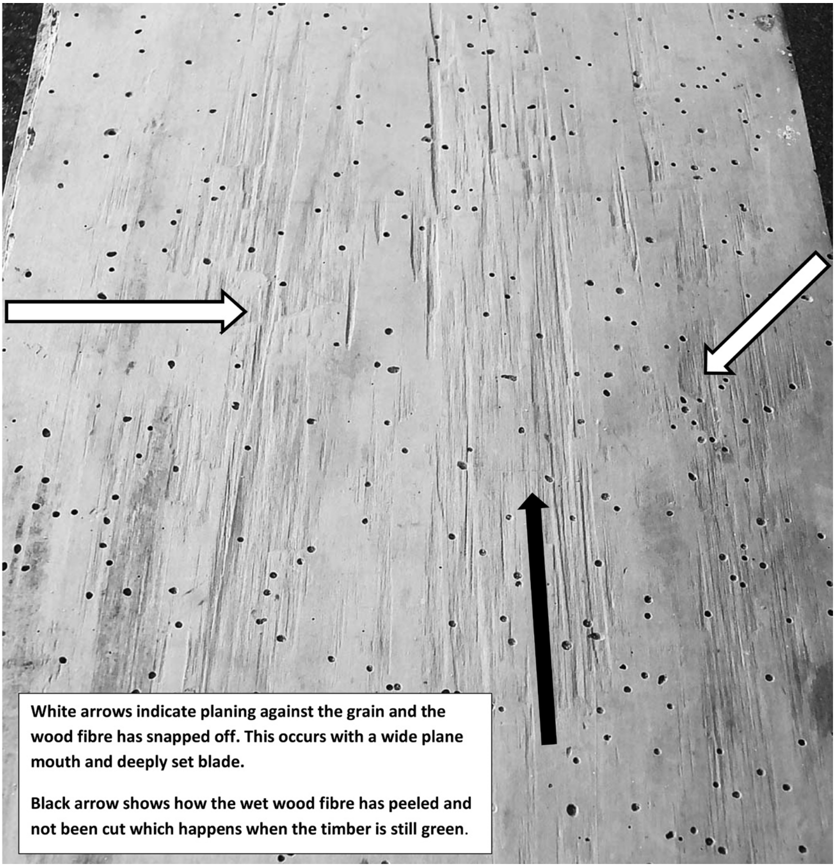

Figure 9. Break-outs caused by the plane's blade being set too deep. Tear marks indicate that the wood was planed too soon after the tree was felled.

This board has been tongue and grooved along its opposite edges and intended to inter-lock with partner boards either side. The purpose is so that multiple boards behave in unison with mutual strength, as in wall panelling or flooring and for draught proofing. This is ideal in housing. Again these have been hand-planed and this time with a matched set of male and female planes (Figure 10). Evidence for this can be seen as small ripples or chatter marks from aggressive cutting (Figure 11). Again, this signals very thick shavings breaking forward with the grain. The shavings are partly being cut and partly splitting with different surface tension on either side of the shaving too great to allow an even curl. The edge of the newly created tongue has been bevelled with a flat soled narrow shoulder plane to allow it to easily mate with a similarly internally bevelled groove (Figure 12). It can be further seen that the edges of the board had been first planed on the long jointer or try plane. Unlike the short 8 inch (or 200 mm) smoother, its 2 foot (600 mm) sole rides and cuts only the high spots to flatten them.

Figure 10. A matched pair of tongue and groove planes by John Green, London, c.1780.

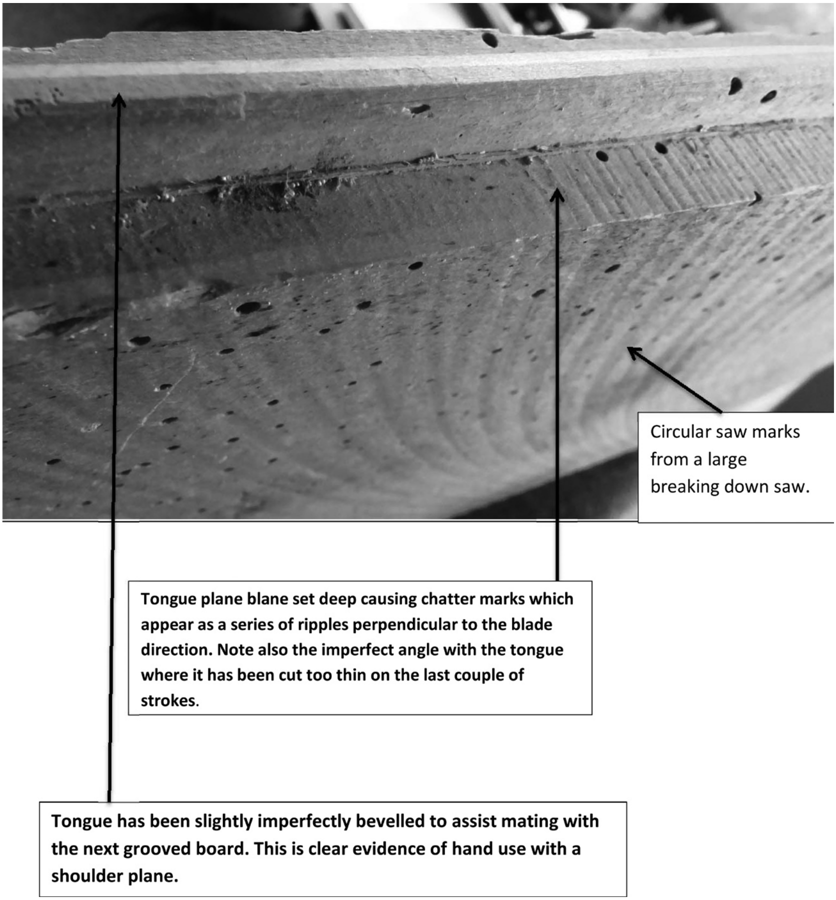

Figure 11. Chatter marks clearly indicate a hand-planed tongue.

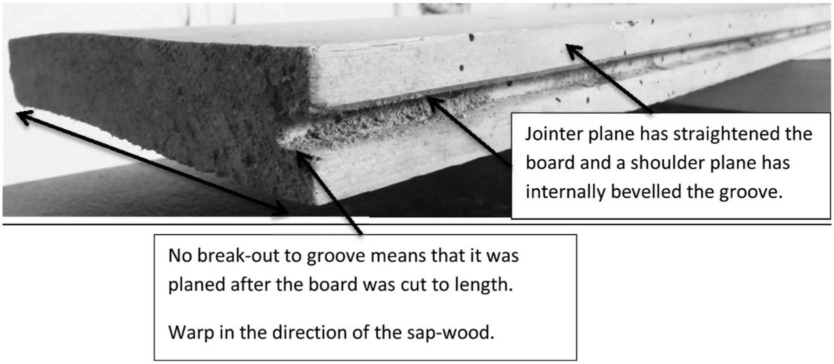

Figure 12. Hand saw marks to the board end but no break-out in the groove indicate that planing occurred after cutting.

Had the cabinet-maker desired to shape a facing edge to the board he would have used a moulding plane. The sole and blade of each plane was profiled to cut a particular fashionable shape of which there are many variations (Figure 13).

Figure 13. Grecian ogee moulding plane sole, c.1820.

This was quite a long discussion about a small board but we have indeed collated a surprising amount of material from it.

1. It is kahikatea, a timber with a preference for wet, low-land soils.
2. Its sapwood was used in earlier colonial buildings without treatment before its poor longevity was understood. This is evident in the woodworm.
3. It was cross-cut into a board on a large powered (6 foot) circular saw.
4. It was cut to length with a hand saw by a right-handed carpenter as indicated by the slope of cut and the breakout to the underside.
5. It was planed after being cut to length as there was no break-out to either the tongue or internally to the groove.
6. There was then a high level of hand work to further process the board for use. It was hand planed with no less than six different planes (scrub, smoother, jointer, male and female tongue-and-groove and rebate). We can conclude therefore that there was no machinery available to much more efficiently do this work.
7. This piece of wood was cut and finished into its final shape soon after the tree was felled. This would strongly suggest that there was not time to wait at least 12 months for this 'seasoning' or drying process to take place.
8. The depth set on various plane blades to remove wood somewhat aggressively suggests that the work was carried out very quickly.
9. The board was used for interior work in a horizontal position with one visible surface.
10. It was never nailed in place but rested on two thin rails at either end. This may imply that it was secure alone in that position or that nails were at a premium and need not have been used.
11. It shows no damage consistent with use as flooring, which was a typical use for tongue-and-groove. Its wear pattern, discolouration and dressed surface contamination all imply that it was probably used as removable shelving.
12. The 'finished' board shows a level of familiarity with tools such as a carpenter would have but falls well short of competent cabinet-making skills.
13. This board has never been painted, varnished, sanded or stripped at a later point. We are looking at an original surface.

Without prior knowledge we have determined a great deal. This particular board in fact came from Pavitt cottage in Robinson's Bay near Akaroa. It was part of a shelf in a bedroom cupboard under a stair case. The house was probably built about 1857-1858 and the Pavitts had their own saw mill powered by a water wheel over a stream adjacent to the cottage. Kahikatea and tōtara once covered much of Banks Peninsula. The first saw mill had been destroyed by fire sometime after February 1855 and a separate fire destroyed the first Pavitt homestead in October 1856. This single well preserved board seems to indicate that they were keen to build a replacement house as quickly as possible. The evidence we can read from the board agrees with the known historical information and this forensic approach also adds significant detail to our understanding of the circumstances in which the board was produced.

Machine tools

Hand work tends to wander around imperfections in the wood structure such as confused compression grain and, more obviously, knotting. Powerful machine guided blades simply over-ride localised density differences. They leave regular and very repetitive patterns with clear signatures.

Machines process wood at a far higher rate than handwork so there is much incentive to utilise them. A single 60 inch or 5 foot diameter steam-powered circular saw rotating at 600 rpm was capable of cutting through 3-4,000 feet of timber per day (*Ashburton Guardian* 27/2/1891: 2). A large band saw could cut a 6 foot diameter log down its length at 20 feet per minute or 2 super feet per second. Even a simple frame or gang saw could cut six boards at 24 inches wide simultaneously at up to 6 feet a minute (Jones et al. c.1910: 266-270, 274, 282 and 289). This compares impressively against an out-put of two pit-sawyers cutting about one super foot (12 inches x 12 inches) per minute in soft woods (Figure 14; ETMooreMFG 2012). In 1823 John Hobbs recalled pit-sawing kauri for the Wesleyan Mission at Whangaroa…. "We cut 10 flooring boards 14 feet long, 9 inches wide and 1 inch thick in the next morning…" (Cottrell 2006: 233). Building historian Nigel Isaacs mentions: "In the mid-1840s, a pit sawyer was paid £1-15-0 per 100 feet in Pigeon Bay, Canterbury, and in Nelson, a sawyer made £80 in five months" (Isaacs 2009: 98). This equates to 4570 feet of hand cut timber, which was not much more than one day's output from a large circular saw.

Figure 14. Random marks from a large two-man pit-saw c.1853.

New Zealand was importing new machinery by the early 1840s so evidence for mechanical saws will be found from the outset of planned settlement:

1. 1838: Mercury Bay, Coromandel
2. 1840: Ngunguru, Whangarei
3. 1841: Hokianga
4. 1842: Manawatu River
5. 1842: Manukau Harbour
6. 1843: Kaiwharawhara, Wellington
7. 1843: Nelson (3 mills by 1845)
8. 1843: Motueka
9. 1849: Leith River, Dunedin
10. 1851: Lyttelton
11. 1854: Sawyers Bay, Otago
12. 1854: Banks Peninsula (Cottrell 2006: 234-235).

The circular saw, as its generic name suggests, has coarse teeth sharpened as miniature chisels around its circumference pointing forward in the direction of rotation. The teeth are ‘set’. That is, each tooth is bent to the side, opposite to its partner ones to create a cut wider than the thickness of the blade. This prevents the blade binding and excessive friction. The ‘valley’ or gullet behind each tooth (particularly) in a breaking down saw is very deep, to accumulate the saw-dust that falls out as the blade clears the log/board underside. This, of course, is true for all wood saws and it is the tooth gauges that are so telling. In fact, only every second tooth cuts the good side as the rest score the waste wood.

The sofa in Figure 15 presents a wealth of evidence. It has pit-sawn rimu internal framing and a heavy circular sawn back rest. Because these surfaces were covered in upholstery they did not need dressing or planing (Figure 16). It had a large selection of handmade and machine-sliced nails, as well as screws made before 1854. The style of the neo-Grecian double-ended swan neck arm rests strongly suggest this was made between 1830 and 1850, the period when this design was most fashionable. It was probably made in Auckland and, given that at least one mill was active in that region by 1842, it may well have been made in the early 1840s. Arguably, it could be New Zealand's oldest sofa. Its scrolled arms were cut by hand on a traditional bow-saw, leaving the typical imperfections of hand work.

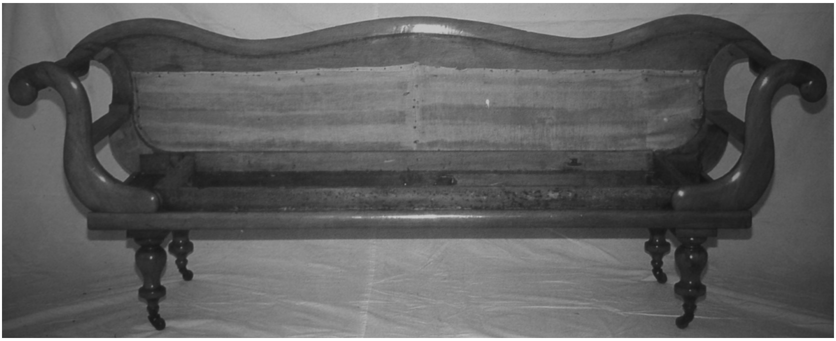

Figure 15. Rimu and kauri sofa, 1842-1845.

Figure 16. The saw marks on the back of the sofa.

The band saw, broadly speaking, is the mechanised advance on the twine-tensioned bow-saw, where the ribbon-style blade is joined into a loop and held rigid between two powered wheels. The blade leaves a perpendicular kerf across the plank with a 'kick' imprint as the slightly stiffer weld passes across the wood face where the two ends have been joined. As with the simpler circular saw, the band saw is extremely efficient and cuts continuously. It was the most expensive saw and is not so commonly found in house timber until the end of the nineteenth century. Large breaking-down saw blades can be 4 inches across and small cabinetmaking workshops were advertising American-made machines by 1875. These were particularly useful for veranda fret-work and barge-board detailing but more commonly used in furniture manufacture for cutting tight curves, such as cabriolled legs, with thin ½ inch blades (Figure 17).

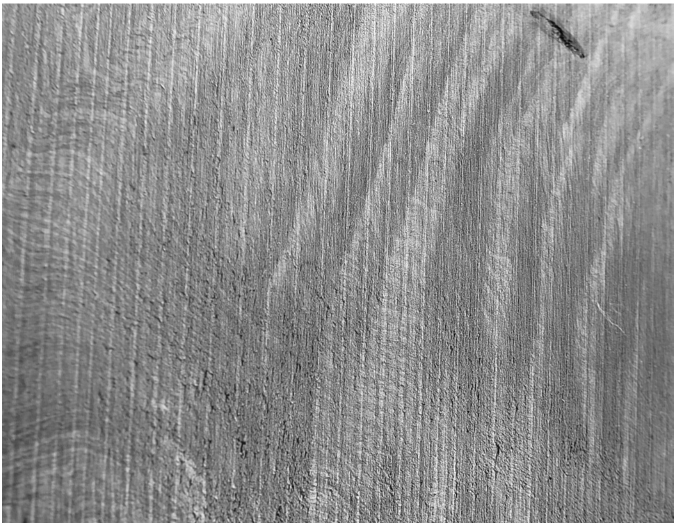

Figure 17. The parallel lines are caused by the weld or join in altering the band-saw blade tension. Each line represents one full revolution. Compression grain to a piece of Southland beech.

The band saw blade signature mark (kerf) could well be confused with the least common saw type found, the reciprocating saw.

The *Lyttelton Times* (14/6/1852: 4) in June 1852 advertised the arrival of just such a reciprocating saw: "The Iron-work of a Vertical SAW-MILL. Cast-iron Slide Frame, Guide Rods, Crank Shaft, Eccentric Rod, Ratchet Wheel, Pinions and Travelling Frame, with Cast Rollers, and one dozen Saws. Gilbert Pickett. Esplanade, May 29."

The blades for the frame or gang saw were mounted vertically and with up to 11 in parallel, capable of cutting ten boards with one pass. Typically the motion was vertical, as indicated in the *Lyttelton Times* advertisement. Alternatively, a planetary gear system connecting the drive shaft to the bottom end of the saw frame would force it through an elliptical path of travel, while an eccentric linkage connecting the drive shaft to the top end of the saw frame required the top end to follow a path of travel resembling a figure eight. The stroke rate was between 100-120 per minute for logs 36 inches across and significantly faster for smaller logs (Isaacs 2009: 99).

Kahikatea boards retrieved from Captain John Parson's Tui's Nest cottage, built in Lyttelton c.1853 (demolished January 2013) display the signature pattern of the "Vertical Saw-Mill" advertised the previous year (Figure 18). The kerfs describe a regular (vertical/diagonal) drag mark consistent with a regulated saw cutting only on the downward pass. Few mills are recorded with the reciprocating saw and this is the first timber has been identified as having been cut by such a saw in the colonial period.

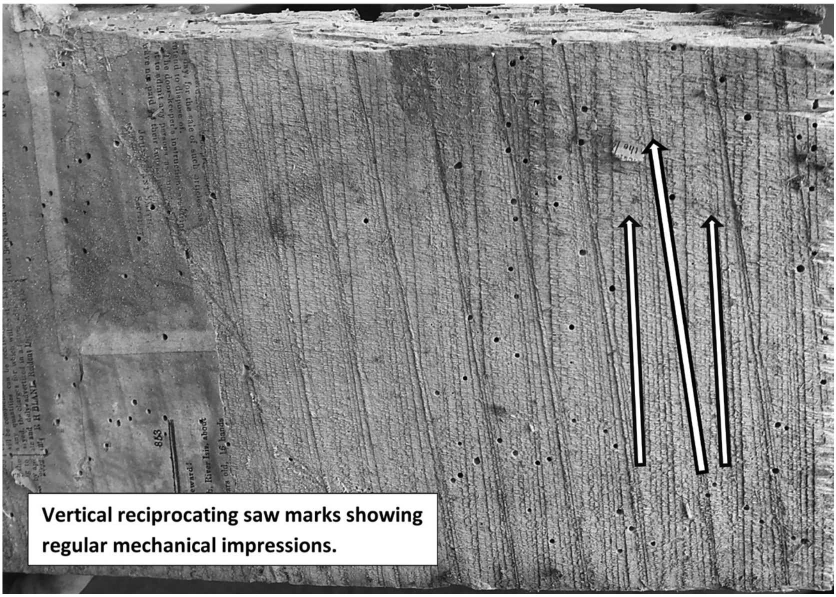

Figure 18. Regular vertical and diagonal marks from a reciprocating saw. Kahikatea wall board from a Lyttelton cottage, c.1853.

Steam engines typically powered most mills and the belt driven arbours were routinely fitted with planing knives and profiled moulder blades for dressing and shaping wood. Planers had two or three long blades mounted into a rotating spindle. As the timber passed under the knives rotating at 700-100 rpm they would incrementally shave a series of shallow scoops across the board width. This system is very effective and the high speed of rotation can make these ripples so close together that they can be quite difficult to detect. In a glancing light they will appear as a series of very fine exactly parallel and regular ridges perpendicular to the grain (Figure 19).

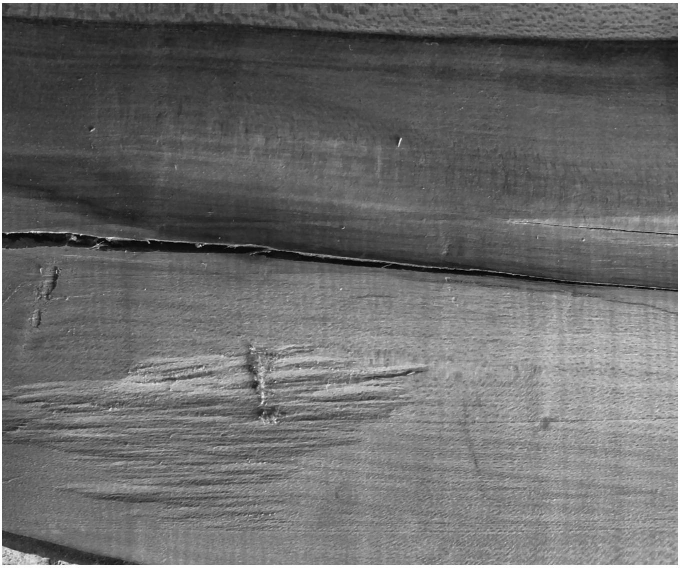

Figure 19. Fine ripples on this piece of birch indicate mechanical planing. The rough area at bottom left is from a chainsaw.

Long-run wood mouldings, such as skirtings and architraves, were made with spinning cutters profiled to the shape desired. Complex mouldings where much wood was removed were achieved by several passes with different cutters, each progressively removing more material. It is possible to detect the demarcation between different blades, as the board minutely wanders between the rollers and guides. Alternatively, individual variations in mouldings, particularly scotias, were made by stacking separate moulded boards together as though they were one (Figure 20).

Conclusion

It is the perfect regularity of any impression that is the hallmark of a machine-powered blade while hand tools leave the unique and individual signature of craftsmen's labour. By identifying blade marks we can occasionally even establish surprising details such as the probable saw-mill the timber came from, as illustrated with the Auckland sofa and the Lyttelton cottage. Those latent marks only determine the gradual change to the efficiencies of mechanisation, but they do also speak of hope, hard work, and a lot of colonial endeavour and, in so doing, connect us to the people who cut the timber and their colonial experience.

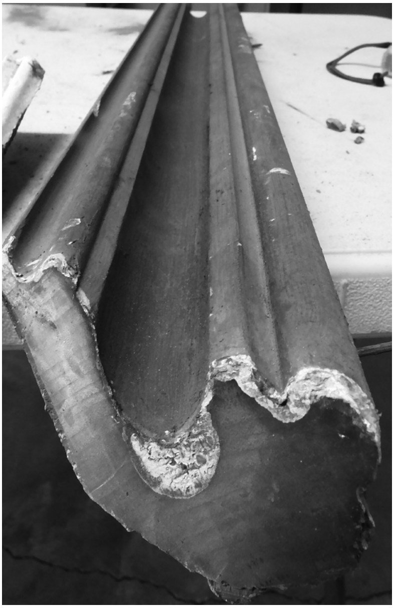

Figure 20. Kauri scotia or cornice moulding probably made with several different cutters, c.1890.

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