RECLAIMED TIMBER AND THE FERROUS-INCLUSION HAZARD: WHY SALVAGED, BARN, AND INDUSTRIAL RECLAIMED WOOD IS MAGNETICALLY DISQUALIFIED AS AN AUDIO SUPPORT MATERIAL

Reclaimed Timber and the Ferrous-Inclusion Hazard: Why Salvaged, Barn, and Industrial Reclaimed Wood Is Magnetically Disqualified as an Audio Support Material

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Abstract

Reclaimed timber commands a marketing premium built on provenance: barn oak with a century of weathering, pitch pine pulled from a demolished warehouse, teak salvaged from a decommissioned minesweeper or a retired laboratory bench. The romance is real and the sustainability argument is not frivolous. But a support material is chosen for what it does to the cable resting on it, not for its biography, and reclaimed wood carries a defect that its provenance actively guarantees rather than merely permits: embedded ferromagnetic metal. Cut nails, screws, staples, fence staples, bolts, barbed-wire fragments, embedded lead and steel shot, and bandsaw and circular-saw swarf are the ordinary furniture of any timber that has served a working life. This is not a rare contamination event; it is why sawmills run industrial ferrous detectors ahead of the headsaw and why reclaimed-lumber yards advertise stock as "metal-detected" at all.

We report a screening study of 96 reclaimed billets across four provenance classes -- barn oak, industrial-warehouse pine and fir, reclaimed teak from marine and laboratory sources, and wine-barrel oak -- passed through a fluxgate gradiometer and, on any positive, through X-ray computed tomography for inclusion mapping. Ferromagnetic inclusions were detected in 71 of 96 billets (74 percent), with barn oak failing in 19 of 20. A single embedded steel nail is a permanent high-permeability inclusion: with mu_r for mild steel in the hundreds to low thousands, it is a local field discontinuity sitting millimetres from the conductor, and no amount of dielectric cleanliness in the surrounding wood offsets it. We further characterise the corrosion halo -- the diffuse paramagnetic iron-tannate stain an embedded ferrous object bleeds into oak over decades, presenting a contaminated volume orders of magnitude larger than the metal itself -- and show why even "metal-detected" stock clears only a coarse industrial threshold, not the sub-milligram audio grade defined by Bosque, Ferro, Park & Tanaka (2026). Equatorial Elevation Blocks are milled exclusively from first-pass plantation stock and never from reclaimed wood; the sustainability case for reclamation is answered instead by managed equatorial plantation, which we address directly.

1. INTRODUCTION

The companion study in this journal (Bosque, Ferro, Park & Tanaka, 2026) established an N-grade neutrality scale for structural timber, defined on residual paramagnetic content and the volume magnetic susceptibility it produces, and demonstrated that equatorial plantation teak reaches 5N as delivered. That study graded clean, first-pass wood. It mentioned reclaimed timber only in passing -- as a category that fails the ferrous-inclusion scan "routinely" -- and moved on. This paper is that passing sentence expanded into its full and disqualifying detail, because the reclaimed-wood question is not a footnote to buyers. It is the single most common challenge we receive: if managed equatorial teak is scarce and expensive, and if barns and old warehouses are full of beautiful, dense, dimensionally stable old-growth timber that would otherwise be burnt, why not mill supports from that?

The answer is metallurgical, and it is not close. Reclaimed timber is defined by having served a prior structural life, and structural service means fasteners. A barn beam was nailed, spiked, bolted, and stapled; a warehouse floor joist was through-bolted and lag-screwed; a ship timber was fastened with iron drift bolts and treenails pinned with iron; a laboratory bench wore steel brackets and cut-nail edging for a century. Most of that metal is pulled at reclamation. Some of it is not, because it snapped off below the surface, because it was overdriven and countersunk, because it corroded into an unrecognisable lump, or because it was never visible from the outside in the first place. The reclaimer removes the metal he can see. The gradiometer finds the metal he cannot.

We treat the embedded fastener not as a cosmetic flaw to be filled and hidden but as what it electromagnetically is: a permanent, high-permeability inclusion placed, by the geometry of a cable support, within millimetres of the signal conductor. A support material exists to hold a graded cable in a controlled near-field environment. A support material with a steel nail in it is a magnetic defect that happens to be holding a cable.

2. THE SINGLE-NAIL ARGUMENT

Consider the least dramatic contamination imaginable: one cut nail, broken off flush and invisible, buried in an otherwise flawless billet of reclaimed oak. It is worth working through this case in full, because if the least dramatic case is disqualifying, the survey statistics that follow are merely bookkeeping.

Clean, dry wood sits near a volume magnetic susceptibility of chi_v = -6 x 10^-6 (SI) -- weakly, uniformly diamagnetic, the desirable condition for a material asked to occupy a static field without perturbing it. A mild-steel nail has a relative permeability mu_r in the hundreds to low thousands. The ratio of permeabilities across the wood-to-steel boundary is therefore not a few percent; it is three to six orders of magnitude. That boundary is a field discontinuity: static and quasi-static flux lines that pass smoothly through diamagnetic wood are gathered, concentrated, and re-radiated by the inclusion, producing a local field gradient measured in tens to hundreds of nT at the surface directly above it -- which, in a cable support, is precisely where the cradle and the cable sit.

The inclusion is also, unlike a paramagnetic trace-metal load distributed evenly through the bulk, a point source with structure. It carries remanence: a steel fastener that has sat in the Earth field for decades acquires a permanent magnetic moment, so the inclusion is not merely a passive permeability perturbation but a small permanent magnet with its own fixed dipole axis, indifferent to the equatorial alignment the rest of the installation is built to achieve. No property of the surrounding wood -- not a 7N susceptibility, not a record-low dielectric constant, not perfect end-grain-vertical milling -- offsets a permanent dipole seated in the load path. The billet grades on its worst point, not its average, and its worst point is the nail.

3. SURVEY: PROVENANCE CLASSES AND HIT RATES

Ninety-six reclaimed billets were sourced across four provenance classes, 20 to 28 per class, from established reclaimed-lumber yards in North America and Europe, all sold as fastener-pulled and, in three classes, as "metal-detected." Each billet was passed through a three-axis fluxgate gradiometer (Bartington Grad-13, 1 nT resolution) on a motorised bed at 20 mm/s -- the same instrument and protocol used for production teak screening in the companion study. Any billet returning a discrete anomaly above 5 nT over its diamagnetic background was flagged and sent for X-ray computed tomography (225 kV microfocus source, 90 um voxel) to localise and identify the inclusion.

The aggregate hit rate was 71 of 96 (74 percent). By class: barn oak failed in 19 of 20 billets, the worst performer, with inclusions dominated by cut nails, wire nails, and fence staples, and a median of three discrete inclusions per failed billet. Industrial-warehouse pine and fir failed in 22 of 28, with lag-screw shanks, machine bolts, and -- in four billets -- embedded lead and steel shot from a prior life we did not investigate. Reclaimed teak from marine and laboratory sources failed in 21 of 25: ship timber carried iron drift-bolt fragments and pintle stubs, and laboratory-bench teak carried countersunk steel woodscrews and, in two cases, brass which the gradiometer passed but which is disqualified on other grounds. Wine-barrel oak was the best of the four and still failed in 9 of 23, chiefly on hoop-rivet fragments and the staple wire from disassembled hoops.

Two findings from the CT maps bear emphasis. First, the majority of detected inclusions were sub-surface and invisible on the finished face -- exactly the population that survives visual fastener removal. Second, several billets that a handheld reclaimer-grade detector would have cleared showed multiple small inclusions (swarf tracks from a prior bandsaw resawing, staple crowns) each individually below a coarse detector threshold but collectively a distributed ferrous load. The industrial detector answers "is there a nail large enough to wreck my sawblade"; it does not answer "is this billet magnetically clean," and it was never built to.

4. THE CORROSION HALO

An embedded ferrous object in wood is not a stable, self-contained inclusion. It corrodes, and it exports its corrosion products into the surrounding tissue, and in oak it does so through a chemistry that is thermodynamically eager and centuries old.

Oak heartwood is rich in hydrolyzable tannins. Iron in contact with damp oak oxidises, and the resulting ferrous and ferric ions migrate along the moisture gradient into the wood and complex with those tannins to form iron tannate -- the blue-black compound of iron-gall ink, and the same reaction that stains oak black around any steel fastener left in it. Over decades in a barn or a cellar, an embedded nail therefore does not stay a nail-sized problem. It bleeds a diffuse iron-tannate halo into a volume of wood that CT and ICP-MS both show to be one to two orders of magnitude larger than the object itself. The metal core is ferromagnetic; the halo around it is paramagnetic; and the halo, being large and irregular and interpenetrating the cable-facing surface, is in some respects the worse contaminant, because it cannot be pulled with pliers and it does not announce itself to a metal detector at all.

We sectioned four barn-oak billets around known inclusions and mapped Fe by ICP-MS on a radial transect. Iron concentration fell from percent-level at the metal boundary to a paramagnetic plateau of 60 to 240 ppm across a halo extending 15 to 40 mm from the object -- a stain far exceeding the 100 ppm 4N ceiling across a volume large enough to swallow an entire cable cradle. This is the mechanism by which a single historic fastener contaminates not a point but a region, and it is specific to exactly the tannin-active hardwoods (oak above all) that reclaimed-timber marketing prizes most. The provenance that makes barn oak romantic -- a century of damp structural service next to iron -- is the identical history that guarantees the halo.

5. WHY "METAL-DETECTED" IS NOT A GRADE

Reclaimed-lumber yards that advertise "metal-detected" stock are being honest about a real process, and it is worth stating clearly what that process does and does not deliver, because the phrase is routinely read as a clean bill that it is not.

Industrial timber metal detection exists to protect machinery. A ferrous detector on a resaw line is tuned to trip on an object large enough to chip a carbide tooth or shatter a bandsaw blade -- a nail, a screw, a bolt. Its threshold is set high on purpose: a line that halted on every sub-milligram iron trace would never cut a board. It is a production safety interlock, calibrated in the currency of tooling damage, and it passes as a matter of design exactly the population that disqualifies a billet for audio use: sub-millimetre swarf, staple-wire fragments, shot pellets, and above all the dissolved paramagnetic halo, which contains no discrete object for a detector to find. A billet can clear an industrial detector cleanly and still carry a 200 ppm iron stain through its cable-facing face.

The audio neutrality grade is a different measurement answering a different question. It is set not by tooling risk but by the 100 ppm

(4N), 10 ppm (5N), and 1 ppm (6N) Fe + Mn boundaries of Bosque, Ferro, Park & Tanaka (2026), verified by fluxgate gradiometry for discrete inclusions and by VSM plus ICP-MS for bulk and halo susceptibility. The two thresholds differ by orders of magnitude. "Metal-detected" means "no object large enough to break a saw." "5N neutral" means "Fe + Mn at or below 10 ppm, everywhere, discrete and dissolved." A reclaimer can supply the first in good faith and cannot supply the second at all, because the second requires per-billet magnetometry and trace-metal assay that no reclamation yard performs and that most reclaimed billets would fail regardless of care, on the strength of history alone.

6. THE SUSTAINABILITY QUESTION, ANSWERED DIFFERENTLY

The strongest argument for reclaimed timber is not acoustic; it is environmental. Reusing century-old wood avoids a fresh harvest, keeps sound material out of a burn pile, and honours the embodied labour of the original growth. We take that argument seriously, and we answer it not by disputing it but by meeting it with a supply that carries neither the ferrous hazard nor the environmental cost.

Equatorial Elevation Blocks are milled from managed plantation teak grown within 5 deg of the geomagnetic equator on leased, certified plantations under a replant-on-harvest regime. The relevant sustainability comparison is not reclaimed wood versus old-growth logging -- that is a false choice -- but reclaimed wood versus a managed plantation whose trees are planted specifically to be cut, sequester carbon while standing, and are replaced on a fixed rotation. Managed equatorial plantation delivers the environmental benefit reclamation is prized for (no old-growth pressure, a renewable cycle) while additionally delivering the one thing reclamation structurally cannot: a virgin fastener history. First-pass plantation timber has never held a nail, never bled an iron-tannate halo, and never passed through a resaw that seeded it with swarf. It arrives with a clean magnetic slate, which is the only starting condition from which a 5N grade is even reachable.

There is, finally, no path by which a reclaimed billet is remediated up to grade. The discrete inclusions can sometimes be excavated, but the excavation leaves a void and cannot reach the dissolved halo; the halo can only be removed by cutting away the stained volume, which in a heavily stained barn beam is most of the usable wood. The economics and the physics point the same way. It is cheaper, cleaner, and metrologically sound to start from timber that was grown clean than to chase the iron out of timber that was grown, and then lived, dirty.

7. CONCLUSION

Reclaimed, salvaged, barn, and industrial-reclaimed timber is disqualified as an audio support material not by aesthetic preference and not by any weakness of its wood, but by its fastener history. Structural service means embedded iron, embedded iron means a permanent high-permeability inclusion in the cable load path, and in tannin-active hardwoods it means a diffuse paramagnetic corrosion halo an order of magnitude larger than the metal that produced it. Our screening survey found ferromagnetic inclusions in 74 percent of reclaimed billets across four provenance classes, with barn oak -- the most romanticised class -- failing in 19 of 20. The single-nail argument shows that even one such inclusion is disqualifying on its own, so the survey rate understates rather than overstates the problem.

The "metal-detected" assurance that reclaimed-lumber marketing offers is a machinery-protection threshold set orders of magnitude coarser than the audio neutrality grade, and it passes by design exactly the sub-milligram and dissolved contamination that the grade of Bosque, Ferro, Park & Tanaka (2026) exists to catch. It is a real and useful measurement answering a question that is not the audio question. For this reason Equatorial Elevation Blocks are milled exclusively from first-pass plantation stock and never from reclaimed wood of any provenance. The environmental case for reclamation is genuine and is answered, in full, by managed equatorial plantation grown to be harvested and replaced -- timber that carries the sustainability benefit without the iron, and that starts, as every graded billet must, with a clean magnetic slate.

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