BRANCH.

METHODOLOGY

Garrett Nelli

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A methodology for sustainable forest management, carbon sequestration, and regenerative design.

This research has been financially supported by the RIBA Research Fund 2022.

This report is the culmination of a 2-year research effort on circular timber design titled *Branching Out: Make Use, Not Waste*

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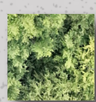
Emmanuel Vercruysse – Architectural Association Hooke Park
Christopher Sadd – Head Forester, Hooke Park
Ben Short – Dorset Coppice Worker, Charcoal Maker, & Author
Pete Etheridge – National Coppice Federation
Jez Ralph & Catherine Byrne – Evolving Forest

First Edition, October 2024

RIBA

BUILDING REGENERATIVE ARCHITECTURE

through



NATURAL CARBON HARVESTING

INDEX

In forsaking mythic imagination for an excess of reason, we have lost things that are our primordial inheritance, things that must be found again if we are to survive this period of impossible tasks. When the weight of the world is on each of our shoulders, mythic imagination can offer more ways to proceed than the narrow paths of logic, reason and fixed belief. For there is a thought in the heart that is connected to the deepest power of humanity, the power of imagination.

BRANCH.

This research delves into the instruments, practices, and techniques that foster more responsible and thoughtful stewardship of our woodlands. By prioritizing forest health, carbon sequestration, and human care, we can profoundly reshape our relationship with the land. Rather than focusing solely on technical advancements in material use or architectural innovations, this methodology embraces a systems-thinking approach—one that ***makes greater use and less waste***.

Across institutions and design practices, passionate individuals are pushing the boundaries of using round and minimally-processed timber in architecture. This research, which began as an audit of the timber production paradigm, examines the challenges, opportunities, and transformative potential that such advancements hold. It offers a critical, imaginative exploration of a future where creativity, respect for nature, and a revitalized connection with the forest guide our social, economic, and spiritual pathways.

A CALL TO THE COMMONS

Once, the forests of England were bustling with life—a shared commons. These woodlands, rich in resources, sustained a wide variety of trades and crafts. From colliers to tanners, herders to huntsmen, the forest was a productive landscape, not just for timber but for the countless byproducts that supported local economies. British woodlands were vital ecosystems where communities and craftspeople sustained a symbiotic relationship with the land.

For centuries, commoners held the right to gather, forage, and harvest, and within this collective stewardship, the forests were maintained. With careful management, these forests could, and should, have been sustained for millennia, so long as extraction was balanced with the forest's ability to regenerate. Yet, the responsibility for overharvesting rested not with the people, but with the magistrates and industries driven by short-term greed, not societal long-term care. The surge of industrialization and the relentless demand for timber to fuel the furnaces of progress drastically reduced England's forest cover—from an estimated **20% in the 1500s to just 5% by the turn of the 20th century**.

The forests we know today—commercialized and fragmented—look, sound, and smell radically different from those pre-industrial woodlands. By the modern age, trades were disconnected from the forest as timber gave way to other modern materials, and many of the traditional forest crafts became obsolete or industrialized. Crafts such as coppicing, hurdle making, charcoal burning, broom making, basket weaving, and producing spars for thatching roofs were once the threads that wove people's lives into the fabric of the forest. They fostered a deep-rooted intimacy with place, a connection that treated the forest not as a wilderness to be preserved but a productive, living system, continuously **replenished by human activity and care**. This was a productive wilderness, where extraction and reverence coexisted.

It is this intimacy to place that my research seeks to rekindle. I propose we deepen our relationship with woodlands—not as a repository of resources but as a collaborative partner in our pursuit of ecological balance. Our focus should be on maximizing carbon sequestration and enhancing biodiversity while fostering cultural and communal practices that support these collective goals. If we aspire for such a shift, then our dependence on timber must adapt accordingly, complementing the forest's health rather than diminishing it.

To expand forest cover, enhance carbon absorption, and reweave culture into these landscapes, we must rekindle the attitudes and practices that once connected people to the woods. This little book, the BRANCH. Methodology, offers a glimpse into such practices—a step toward a future where forestry, culture, and community coalesce to create a sustainable, regenerative relationship with the land

Silence gradually fell on the forest that had rung out for centuries with barking and horn-blowing from the princely chase, with cowherds' shouts, the lowing, whinnying, mooing, bleating and grunting of animals, the axe blows of cartwrights and plank-makers and the pounding of forge hammers, and where on all sides furnaces had smouldered and smoke risen from charcoal piles and tar or ash pits.

FOREST.

To explore the potential of innovative timber products, we must first critically examine our relationship with the forests that support them. Forests are complex ecosystems influenced by a myriad of factors, including economies, cultural histories, climate change, politics, and the intrinsic biological needs of the forest itself. While each of these factors plays a role in shaping forests, the myopic pursuit of industrial interests has overshadowed other considerations.

To achieve a more sustainable and equitable relationship with forests, we must reevaluate our priorities and elevate the forests needs. By recognizing the interconnectedness of forests and the extrinsic dynamics that shape them, we can develop socio-ecological regimes that benefit both humans and the environment - *as it was before*.

CONIFERIZATION & THE COMMONS

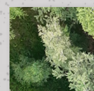
The commodification of forests, particularly through the rise of coniferization, has left deep scars on the environment and culture. Once a shared commons for collective life, forests gradually transformed into commercial assets for timber production in the 1600s onward. This shift from forest as a living ecosystem to commodity fractured the intimate relationship between people and the woodlands, reducing it to mere economic utility, and what was once a communal resource became subject to state and industrial control. The forest gradually became the site of systematically planned timber production, whose only aim was to deliver as much valuable wood as possible.

State forestry offices, originally established to support industries such as mining and foundries, began to assert greater independence by the 19th century, striving to establish forestry as a recognized scientific discipline. The growing need to quantify and manage forests—through calculating wood volumes and growth rates—laid the foundation for the development of

Medieval tapestry depicting woodcutting, forest labor, and varies craftspeople

modern forestry practices. However, this reliance on mathematical precision often clashed with the organic complexity of forests and encouraged simplistic practices like clear-cutting and the establishment of single-species stands. Forests became easier to measure and manage, but at the cost of biodiversity and ecological health - an illusion of control.

The rise of coniferous plantations, particularly pines, reflected the economic pressures of the time. Pines were favored for their rapid growth and ability to thrive in poor soils, which made them ideal for industrial output. Despite mixed forests being valued in theory for their ecological resilience, the drive for economic efficiency favored monocultures.



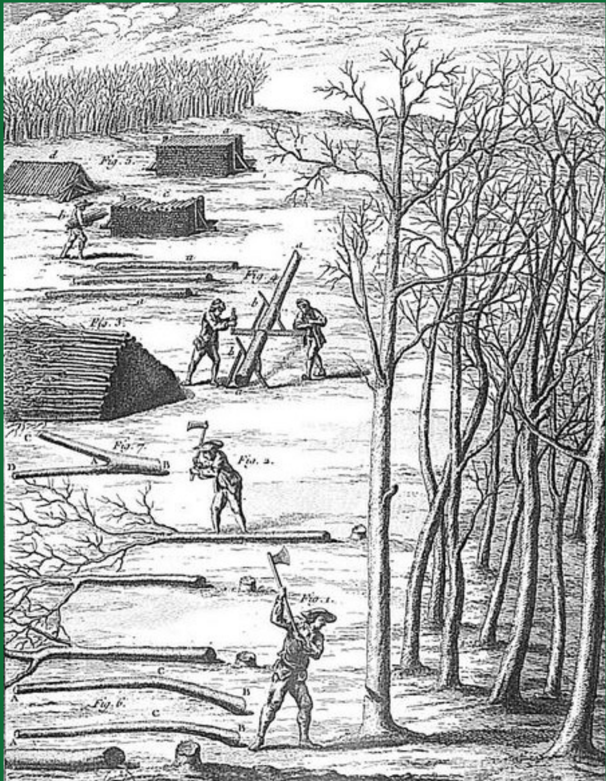
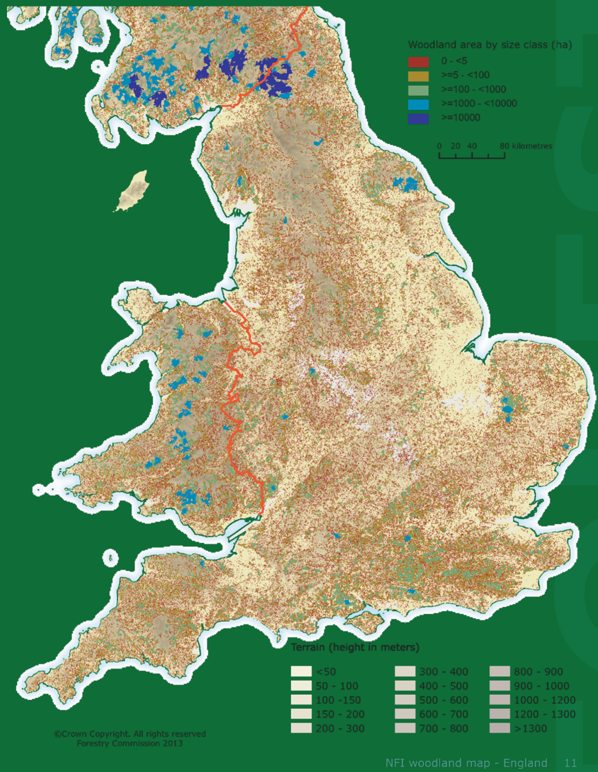


Illustration from 1764 by B.L. Prévost and H.L. Duhamel du Monceau, depicting plantation methods of and forest management

This coniferization of forests across Europe, justified by economic arguments and bolstered by scientific forestry, dramatically altered the landscape. The preference for conifers, driven by the desire for higher profits and ease of management, came at the expense of diverse ecosystems and the cultural practices that once relied on hardwoods for their fruits, foliage, and timber. Over time, this shift not only reshaped the forests themselves but also eroded the relationship between people and the land. Historically, around **30-50%** of England's population in the 1500s had direct economic ties to forests, engaging in a wide range of trades reliant on broadleaf trees. Today, with the widespread shift toward industrial forestry, the rise of conifer plantations, and the reduction in forest crafts, less than **1%** of the population has any direct economic connection to forests.

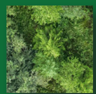


Distribution of woodland by size

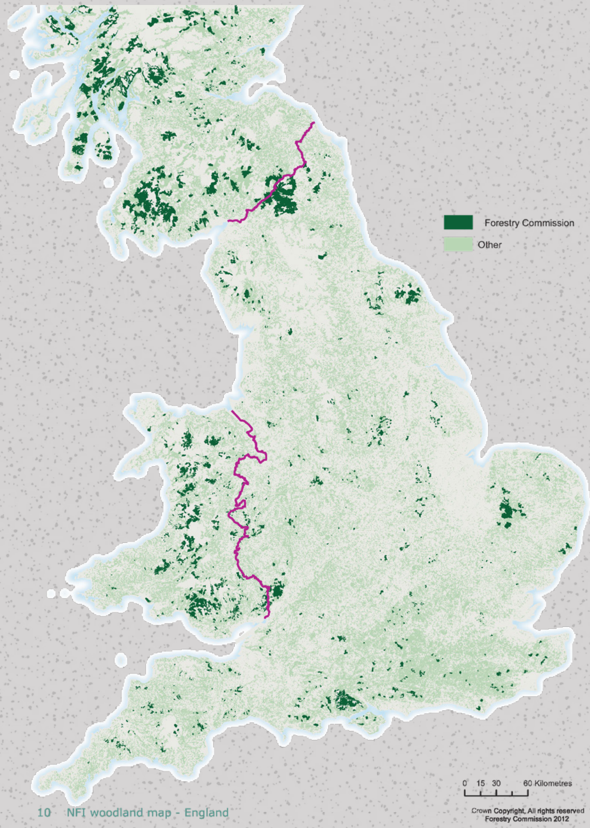
STATE OF UK WOODLANDS

A forest is more than just a concentration of trees; it is an ecological condition. Simply planting more trees does not necessarily create a thriving forest. The UK, an island that has essentially felled all of its old-growth forests is now undertaking the slow, careful process of regenerating biodiverse, carbon-sequestering woodlands. The UK's tree cover goal is to increase from **14.5% in 2023 to 16.5% by 2050**. While this is an ambitious and important metric to track, canopy cover alone overlooks crucial factors dictating the current condition of UK woodlands.

According to the Forestry Commission's 2020 report, around **78% of UK woodlands are smaller than 5** hectares and collectively account for over 60% of the total woodland area. Furthermore, 94% of all woodlands are less than 50 hectares in size—what could be considered a modest-sized forest. For comparison, the average woodland size in the United States is approximately 55 hectares. Whether viewed from an aerial map or on a drive in the countryside, it is evident that the UK's landscape is characterized by fragmented pockets of forests, separated by development and agriculture. Additionally, about 40% of England's woodlands are not actively managed, posing significant risks to biodiversity and vulnerable to pests and disease.



Reclaiming marginal lands for future forest growth is essential. Even more critical, however, is the creation of diverse, thriving woodlands within these limited spaces, coupled with a reimagined approach to reconnecting fragmented forest patches into a unified, cohesive ecosystem. Nature does not adhere to man-made boundaries, so creating ecological corridors that allow for connectivity between fragmented woodlands is vital. The UK has an average of about 53% of its biodiversity left, well below the global average of 75%. With 1 out of 6 species at risk of being lost, these corridors can serve as critical ecological infrastructures for species health. This integration fosters biodiversity, allowing species to move



Distribution of woodland ownership

blue bells emerge within beech forest

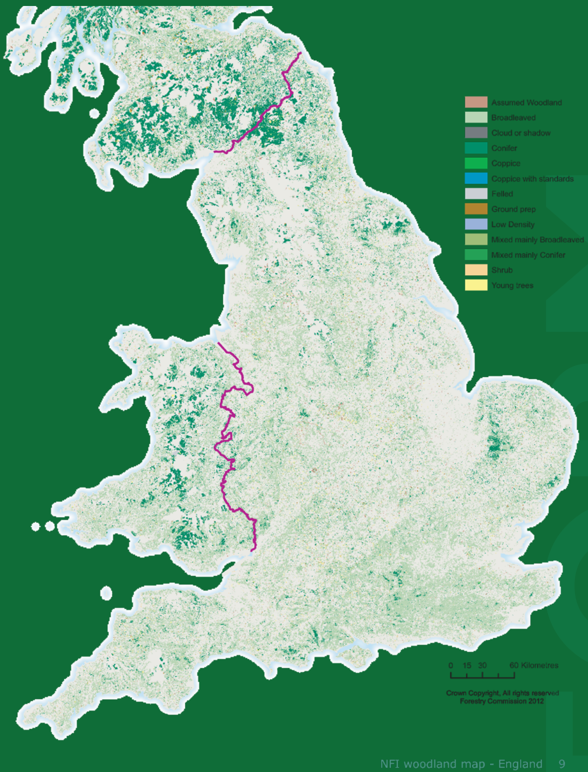
freely, and ensures the ecosystem functions as a collective whole rather than isolated parts.

With **46% of UK woodlands privately owned,** there is an opportunity to create incentive-driven management practices that could accelerate the regeneration of these woodlands, putting the power back in the hands of communities.

CLIMATE ADAPTATION

The UK is the third-largest importer of forest products globally, with **80% of its wood being imported**, largely C24-rated softwood, which dominates the construction industry. Despite this, only 8% of the timber produced domestically is hardwood, highlighting the country's reliance on imported softwoods. Meanwhile, woodland biodiversity is in decline, and the majority of England's woodlands are still not classified as sustainably managed. The UK faces a growing need to manage its forest to meet rising timber demand and increase biodiversity.

At the same time, climate change is driving **tree migration** across Europe, with species like conifers shifting northward and broadleaf trees moving westward. This shift calls into question the future viability of monoculture conifer plantations. These plantations, dominated by species like Sitka spruce, are highly vulnerable to the changing climate. Sitka spruce, with a growth rate of YC12 (12 cubic meters per hectare per year), has been favored for its fast yields, particularly in



Total woodland: 3,150 thousand hectares

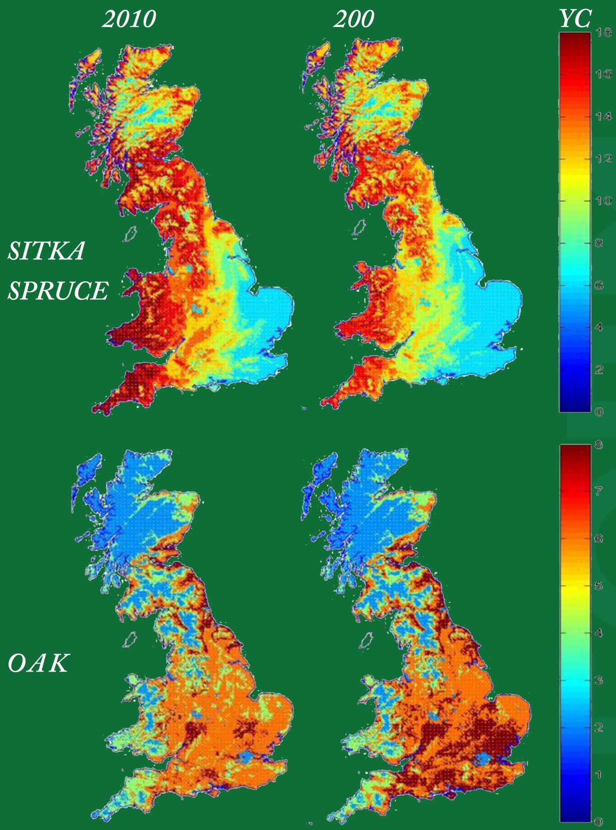
Conifers: ~1,740 thousand hectares

Broadleaf: ~1,410 thousand hectares

Distribution of woodland type

cooler, wetter regions like Scotland and Wales. However, as the UK's southern and central regions become warmer and drier, spruce is expected to suffer from increased drought stress, pest infestations, and reduced yields. Its preference for cooler, moist climates makes it less suitable for large portions of England, especially with the anticipated rise in temperatures and more frequent droughts.

In contrast, native hardwoods like oak are better suited to these warmer conditions. Oak's deeper root systems allow it to access water more effectively during droughts, making it a more resilient species for the projected climate of southern and central England. Though oak has a lower growth rate of YC4 (4 cubic meters per hectare per year) compared to spruce, its denser wood (0.56 t/m^3) and adaptability make it a valuable species for the future. Regions like the Midlands, southern England, and parts of East Anglia are expected to experience improved growing conditions for oak and other broadleaf species, making these areas prime locations for future hardwood planting.



The impact of climate change on UK tree growth

With timber demand projected to **increase threefold by 2060**, the UK must pivot toward planting and managing native hardwoods, which not only perform better in a warming climate but also sequester twice as much carbon and enhance biodiversity. By prioritizing resilient hardwoods such as oak, sweet chestnut, and beech, the UK can foster a more sustainable timber industry, decrease dependence on imports, and enhance long-term forest health while contributing to climate mitigation efforts.

THE CARBON FOREST

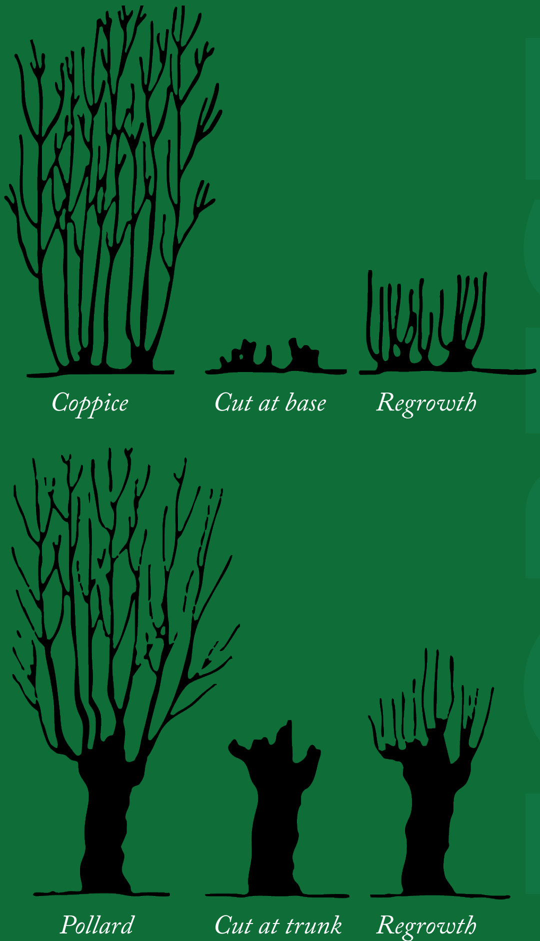
Clear-cutting, once valued for its economic simplicity, has faced widespread criticism due to its significant ecological consequences. These include soil degradation, the destruction of wildlife habitats, turning forests into carbon emitters, and diminishing the land's water retention capacity. The long-term environmental costs far outweigh its short-term economic gains. In response, there has been a growing shift toward more sustainable management practices, such as **Continuous Cover Forestry (CCF)**.

Continuous Cover Forestry (CCF) is widely recognized as a more sustainable approach, maintaining the forest canopy while selectively harvesting a small percentage of trees each year. This method minimizes ecosystem disruption, allowing sunlight to penetrate the canopy, which fosters groundcover growth and supports diverse species. The gradual thinning process promotes natural regeneration while enabling forests to continue functioning as vital carbon sinks. Estimates suggest that CCF can sequester up to **126 tonnes of carbon per hectare over 50 years**, compared to **70 tonnes per hectare under clear-cutting.**

An even older and non-destructive form of forest management is the practice of **coppicing** and **pollarding**. These ancient techniques leverage the regenerative capacity of broadleaf species such as hazel, oak, and sweet chestnut. By cutting trees down to their base (coppicing) or to a higher point (pollarding), the trees regrow multiple shoots, producing dense, straight wood on short cycles of 5, 10, or 20 years, depending on their intended use. Remarkably, even certain conifers like Douglas fir and cedar exhibit this regenerative growth. This method preserves the tree's root system, leaving much of its carbon storage intact—around 50% of a tree's carbon is stored in its roots—while supporting both aboveground and underground ecosystems.

Hardwoods play a crucial role in carbon storage due to their complex structures and extensive biomass distribution. A large portion of their carbon is stored in branches, twigs, and leaves, as hardwoods have more intricate crowns compared to conifers. For comparison, hardwoods can contain up to 40% of above-ground biomass in secondary stems, branches, and leaves, as opposed to 20% with confiers. Additionally, hardwoods have deep root systems that store significant amounts of carbon underground, with decaying roots contributing to long-term soil carbon storage.

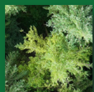
Moreover, hardwoods generate substantial leaf litter, which decomposes into organic matter, enriching the soil's carbon content. The slower decomposition rate of hardwood leaves compared to conifer needles results in prolonged carbon retention in the soil, further enhancing their role in carbon sequestration. This combination of above-ground and below-ground carbon storage makes hardwoods essential for long-term ecosystem carbon dynamics.



COPPICE REGENERATION

Coppice woodlands hold immense cultural and ecological significance, having been intricately tied to human life in the UK since Neolithic times. Ancient structures like the trackways in the Somerset Levels, built from coppiced wood, provide evidence of early use, while historical studies suggest that most woodlands were actively coppiced from the Middle Ages to the late 1800s. Coppice woodlands support specialist species and promote biodiversity, making them ecologically valuable. Despite their historical and ecological significance, the extent of coppice woodlands has dramatically declined, with recorded cover falling from **230,000 hectares in 1905 to just 2,913 hectares by 2021**, most of which is now concentrated in southern England.

The decline of coppicing can be attributed to several factors, including the 20th-century shift toward productive conifer plantations, the advent of mechanized harvesting, and the rise of plastic and metal alternatives to traditional coppiced wood products. Additionally, the lack of long-term security for woodland tenancy—coupled with the extended time required for coppicing to return to rotation—and limited coppice-specific funding have further contributed to its decline. Despite these challenges, a small but vital workforce of 201 to 500 coppice workers remains active. Coppicing is particularly suited to small woodland plots and historically provided firewood and small-diameter timber through short rotation cycles. Extending these rotation cycles, however, could significantly enhance carbon storage while improving wood quality for modern applications.



Although often overlooked as a modern forestry practice—particularly for producing construction-grade timber, which remains a national priority—recent initiatives are reevaluating the potential of coppicing. The National Coppice Federation, supported by significant funding from the Forestry Commission's Woods Into Management Forestry Innovation Fund, has undertaken efforts to map and assess coppice woodlands across England. By May 2024, the project had surveyed 3,727 hectares of privately owned woodland, identifying 3,029 hectares as active or restorable coppice—a figure over six times higher than that reported in the 2021 National Forestry Inventory dataset. This demonstrates that while underutilized, coppicing persists across Britain and offers a promising opportunity to revitalize derelict woodlands.

coppice cut in the spring

coppice 1 year later

sweet chestnut coppice after harvest

The study revealed that many coppice woodlands are currently out of rotation, but with the right incentives and support, these areas could be restored to play a significant role in carbon sequestration and the timber economy. While fast-growing species like pine and larch reach maturity in around 30 years, slower-growing species such as beech may require over 100 years, indicating that extended rotation cycles could enhance both carbon storage and timber quality within coppice systems. Since coppices can thrive on plots as small as a hectare, reintroducing coppice management provides a sustainable and productive strategy for revitalizing the fragmented British woodland landscape. By ensuring that coppice woodlands remain a vital component of the future of UK forestry, we not only advance environmental goals but also preserve age-old traditions and the folk crafts intimately connected to the land.

It suggests that digital technology and material-driven practices, connected in an intricate web of mutually dependent relationships, can drastically change our ways of thinking about architectural design as a form of cultural expression.

FORM.

Does form follow function, or does function dictate form? In forestry, the demand for standardized lumber in construction has shaped forests into factories engineered to produce straight, knot-free timber. This has resulted in widespread ecological degradation, heightened carbon emissions, and a severe decline in biodiversity. In the UK alone, populations of native birds and butterflies have been nearly halved, sacrificed to the proliferation of monoculture forests.

To rehabilitate our woodlands, we must reverse this paradigm—allowing forest function to shape their form. Are we ready to embrace the challenges of working with trees in their natural complexity, prioritizing diverse hardwoods over uniform, fast-growing conifers? Can we adapt our construction practices to integrate irregular, heterogeneous woodland products? And when felling is necessary, can we honor the entire tree by maximizing its use and minimizing waste? These are the challenges—and opportunities—that designers and foresters must confront.

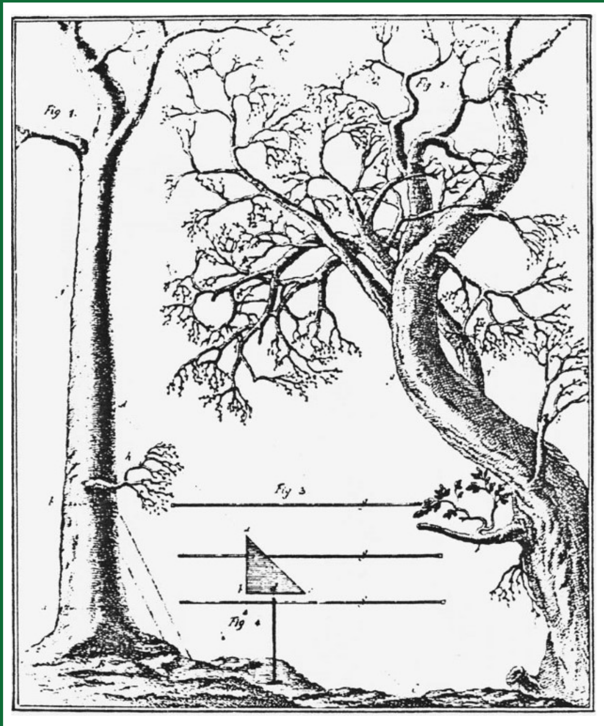


Illustration from Duhamel du Monceau's Forest Labor (1766–67) showing tree volume calculation. Straight trees were easy to measure, while crooked ones, though challenging, were prized in shipbuilding.

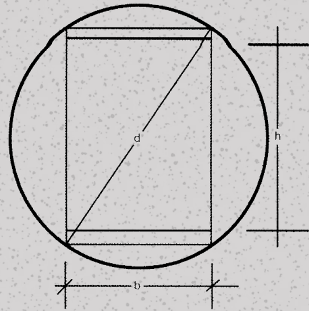
MAKE NO WASTE

In the modern forest-to-timber paradigm, the drive to maximize yield has led to the homogenization and standardization of timber products. This industrial process has prioritized transforming round logs into rectilinear shapes, with the ubiquitous 2x4 emerging as the universal standard due to its replicability, versatility, and ease of use. However, this pursuit of standardized timber has come at a significant, often overlooked cost: on average, **60% of a tree's biomass is wasted during the milling process**. Furthermore, the structural integrity of the timber is compromised as its natural fibers are severed to conform to rigid, right-angled shapes, disregarding the inherent strength of the tree's naturally round form.

When a tree is felled, approximately 30% of its biomass is left on the forest floor as residue, including small branches, bark, and broken limbs. This figure does not include the roughly 50% of the tree's biomass found below ground in its roots, which is typically left to decompose. Once the logs reach the mill, an additional 20–30% of the material is lost during processing. Although some of this waste is repurposed for biofuel, paper pulp, or panel products like OSB, these secondary uses have developed as byproducts rather than being integral to the forestry or milling process. This highlights the inefficiencies and missed opportunities inherent in the current system.

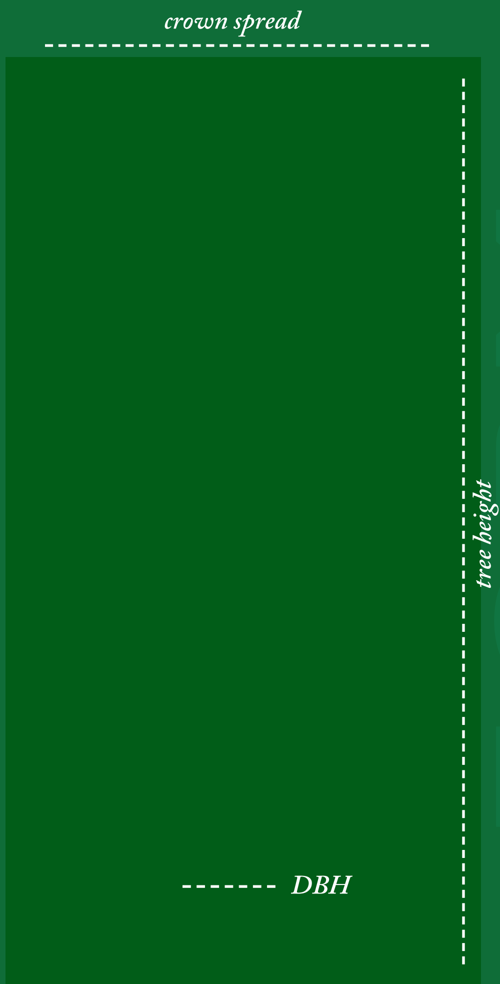
forestry residue

Adding to this, building codes often mandate over-engineering, with C16 and C24 structural-grade timber universally specified, even in cases where lower-grade wood would suffice.



Rectangular section limited by small-end diameter (d) and standard dimensions (b x h).

Research shows that small-diameter round timber beams, even with natural tapering, maintain remarkable strength and stiffness compared to milled lumber of equivalent dimensions. This is because round wood preserves its natural fiber alignment and density, which enhances its load-bearing capacity and resilience under stress. In fact, the compressive and bending strength of round wood can exceed that of milled lumber by up to 50%, as its fibers remain intact and unsevered. Additionally, round timber beams require significantly less processing, reducing waste and preserving the wood's inherent properties. These findings highlight that, when utilized thoughtfully, round wood offers a structurally advantageous and ecologically sustainable alternative to milled timber.



VOLUME ASSESSMENT

Assessing forest biomass and individual tree volume has historically been one of the most complex challenges for foresters. This difficulty stems from the diverse growth patterns of different tree species, each influenced by unique local light conditions and microclimates. As a result, no two trees grow identically, even in industrialized plantations. To overcome these challenges, foresters have developed allometric metrics to estimate biomass and volume more accurately.

Key measurements for assessing trees include tree height, the vertical distance from the base of the tree to its highest point, and tree girth, typically measured at 1.3 meters above the ground and referred to as **DBH (Diameter at Breast Height)**. Remote tools such as monoculars, photogrammetric interpretation, or electronic surveying instruments are used to measure the tree's diameter. Another important metric is crown spread, the plan area diameter of the tree's canopy, which provides insights into the tree's overall size, health, and ecological impact.

Foresters use diameter and height measurements to estimate the lumber yield of individual trees and, by extension, predict the total wood content of a forest area, referred to as a stand. Tree volume is calculated in cubic meters using the tree's diameter at breast height (DBH) and overall height. To account for the natural taper of the trunk, specific formulas are applied, often incorporating species factors to adjust for differences in growth patterns and wood density.

The formula used to calculate tree volume from DBH and height typically follows these steps:

- *Measure DBH (Diameter at Breast Height), typically 1.3 meters (4.5 feet) above the ground*
- *Measure the tree's total vertical height*
- *Calculate radius by dividing the DBH by 2*
- *A=πr /2, Use the radius to find the cross-sectional area at DBH.*
- *Estimate the tree's volume by factoring in the height and adjusting for taper using a factor of 4 in the equation: V = A x height/4.*

In the UK, foresters also estimate tree volume using the **Hoppus foot**, a traditional measurement that reflects a piece of timber measuring 1 foot by 1 foot by 1 inch thick, adjusted to account for the material wastage that occurs when converting round logs into square beams.

- *Volume (in Hoppus feet) = (DBH in inches)^2 / 144 * Height in feet*

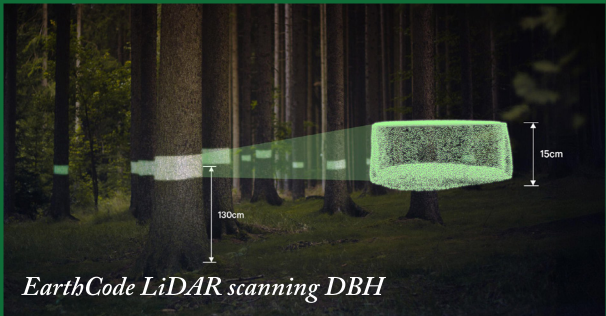
This formula provides a practical way to estimate timber yield, complementing the volume calculations expressed in cubic meters (m^3) used for broader forest management purposes.

aerial scan of forest plot

MEASURE THE UNMEASURABLE

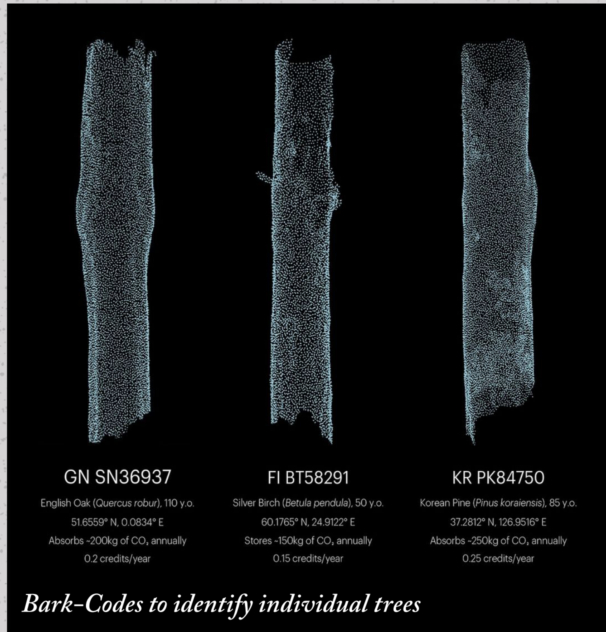
Trees exhibit an extraordinary variety of forms, each with unique structural complexities that pose significant challenges for volume measurement. While single-trunk trees are the standard for many calculations, more complex forms, such as multi-trunk trees and clonal coppices, require specialized approaches. One of the most difficult aspects of assessing tree volume and biomass is accurately accounting for the often substantial volume of limbs and branches. This is especially true for mature hardwoods, which frequently have branch and limb volumes that surpass the volume of their main trunk. For example, the Middleton Live Oak was recorded with a branch volume of 3,850 cubic feet (109 m^3)—more than four times the volume of its trunk, which measured 970 cubic feet (24.5 m^3).

Assessing forest stand biomass using traditional measurement methods presents significant challenges, particularly when dealing with the complex geometries of natural forests. This is where modern technologies, such as **terrestrial and aerial LiDAR** scanning, have become invaluable. LiDAR systems utilize laser pulses to generate highly detailed 3D models of forests, accurately capturing the entire structure of individual trees, including their trunks, branches, crown areas, and exposed root systems. These advanced models provide a far more precise and comprehensive representation of total biomass, revolutionizing forest management and ecological research.



EarthCode LiDAR scanning DBH

A study conducted by University College London (UCL) utilized terrestrial laser scanning (TLS) to reassess biomass estimates in UK temperate forests. The study found that TLS-derived above-ground biomass (AGB) was 409.9 tonnes per hectare (t ha−1), which is **1.77 times greater** than current allometric model estimates. These discrepancies primarily arise from biases in traditional models that were calibrated using smaller and more uniform trees of the plantation forest structure. The study emphasized that larger trees, which now dominate UK forests, are severely underrepresented in allometric calibration datasets.



Bark-Codes to identify individual trees

aerial scan of Hooke Park, 150 Hectares reconstructed from over 10,000 drone images

For instance, less than 7% of trees—typically larger than those accounted for in standard allometric models—were found to contribute 50% of the above-ground biomass (AGB). This deviation from size-invariant scaling relationships exposes significant shortcomings in current biomass estimation methods. Consequently, these inaccuracies have a profound effect on carbon accounting for the UK's temperate forests, as larger trees play a disproportionately vital role in carbon sequestration and ecosystem health.

The study recommends prioritizing more precise measurement techniques like TLS to improve the characterization of biomass and address uncertainties in the UK's carbon sink capacity. In addition to its value in accurately calculating above-ground biomass (AGB) and carbon storage potential, TLS technology enables the creation of 1:1 digital twins of living trees, which can be utilized to enhance the fabrication and milling processes.

volume assessment

LiDAR AGB
1,656kg

traditonal AGB
2,102kg

Beech
SW England
65 yr old
height : 21m
DBH : 40 cm
traditional volume : 2.3 m^3
LiDAR volume : 2.96 m^3

not to scale

LiDAR AGB
4,657kg

traditonal AGB
3,825kg

Oak
SW England
50 yr old
height : 25m
DBH : 50 cm
traditional volume : 5.1 m^3
LiDAR volume : 6.21 m^3

not to scale

61

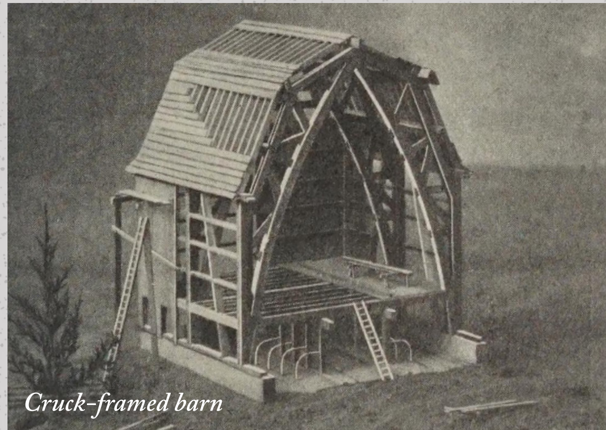
the "Tree & the Truss" research prototype

ADAPTABLE, MODULAR, ASSEMBLAGE

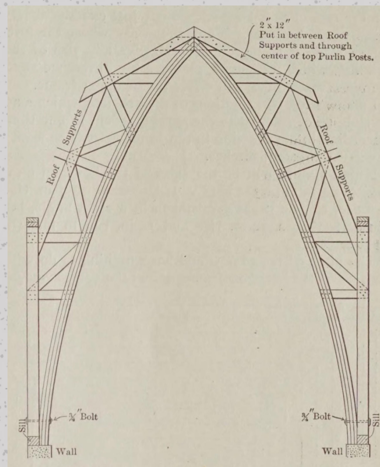
Fabricating, processing, and milling irregular timber geometries traditionally relies on highly skilled craftsmanship. Historical structures, such as cruck-framed barns, exemplify this ingenuity—bent timbers were split in half to create "A" frame roof trusses, assembled on the ground, and lifted into place. This approach maximized the utility of non-linear yet structurally robust timber. Similarly, using small-diameter roundwood for structural frames demands both technical expertise and creative design solutions. The primary challenges with small-diameter roundwood lie in its short usable lengths, typically between 0.5 and 2 meters, and the intricacy of crafting end joints that seamlessly connect to larger structural components like columns or trusses. These limitations make a modular assemblage approach essential, combining multiple smaller pieces into cohesive and strong structural systems. To scale this practice, industrialized and repeatable processes are crucial for efficiently crafting complex end geometries across many uniquely shaped timber members, enabling broader adoption of irregular timber in construction.

At the Architectural Association's Hooke Park campus, the Design + Make program has been pioneering innovative ways to transform waste timber into large-scale architectural prototypes. Leveraging an industrial robotics cell equipped with an Ensenso N30 structured light scanner, a mechanical lathe, and a KUKA robotic arm, the team has developed automated workflows to process non-standard beech crown branches into precise structural components for space-frame systems. The system operates through Python and C# scripts within a Robot Operating System (ROS), enabling real-time communication between the vision system and the robot. This allows for the generation of precise toolpaths to cut targeted joinery at the ends of

Installation by Bob Verschueren

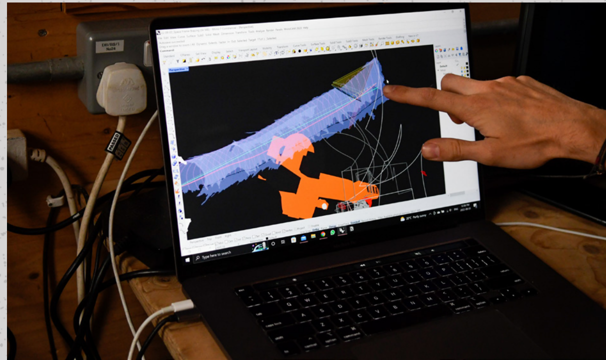


Cruck-framed barn



each branch. Point clouds from multiple scans are meshed and transferred to Grasshopper via the COMPAS plugin, where the geometry is analyzed, documented, and fitted with standardized components. This process ensures the accurate placement of in-plane tenon joints along the branches, minimizing geometric conflicts and optimizing their integration within the structural system. By combining advanced robotics with computational design, the program demonstrates a scalable, sustainable approach to processing irregular timber geometries.

The robotic workflow produced 256 identical components from varied branch timber, utilizing precise cuts made with a spindle-mounted rotating



saw and an in-house pneumatic gripper. This approach balances efficiency and sustainability by avoiding full automation of truss assembly or exhaustive internal timber analysis. Instead, it emphasizes the precision of connection details, leveraging the natural strength and geometry of round timber. The resulting components can be easily assembled on-site, functioning as a kit-of-parts that minimizes construction complexity.

A later development in this workflow, the *Tree and the Truss* prototype, combines secondary trunks with dimensional timber, seamlessly blending natural and man-made geometries. Smaller-diameter branches are utilized as truss braces, providing a material-efficient

alternative to traditional secondary timber supports by repurposing undervalued waste wood. This innovation demonstrated that using branch timber in place of dimensional lumber could reduce the need for felling mature hardwoods by as much as two-thirds. When scaled up to an industrial production workflow, this approach could **increase tree stock by 200%**, reducing the strain on forest ecosystems. From a carbon footprint perspective, a 5m x 5m truss system made from branch timber has approximately 30% of the footprint of a dimensional timber counterpart and only 8% of a steel-braced system. By combining ecological sensitivity with innovative engineering, such approaches pave the way for future advancements in eco-design.


the Field Station design-build project at Hooke Park

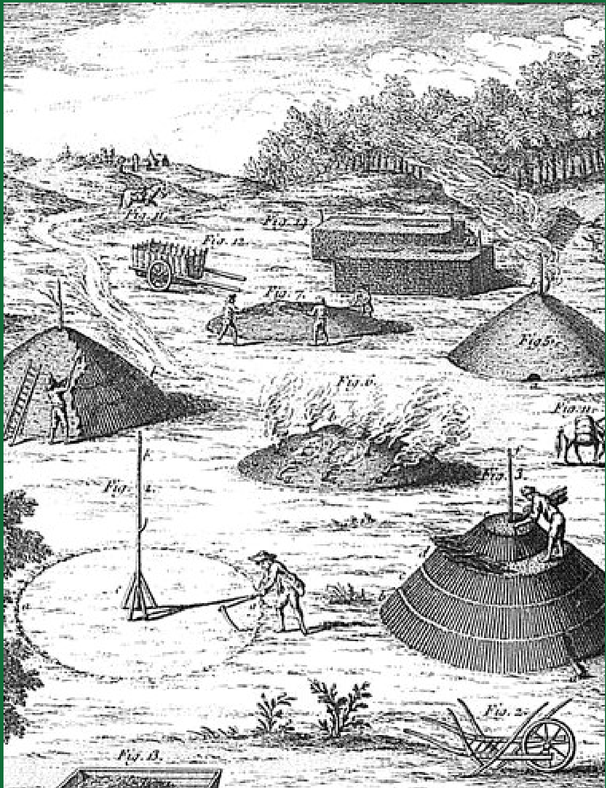


Illustration from 1764 by B.L. Prévost and H.L. Duhamel du Monceau, showcasing charcoal production techniques in the 18th century.

Even with reduced material wastage, certain parts of a tree remain unsuitable for construction and are better repurposed than left to decay. Within the carbon sequestration marketplace, pyrolysis—the process of converting woody biomass into solid carbon—has emerged as a valuable climate solution. This ancient method, historically used to produce **charcoal**, is now being advanced to create **biochar**, a modern tool for carbon storage and soil improvement.

Charcoal production involves heating wood or forest residue in oxygen-starved conditions at temperatures above 400°C (750°F). This process produces a carbon-dense fuel with a high energy yield, traditionally used in industries like iron and steel due to its ability to burn at over 1,100°C. With an energy value of approximately 8,140 kilowatt-hours (kWh) per tonne—compared to 4,100 kWh for solid wood—charcoal remains an efficient and enduring fuel source, showcasing its potential for both historical and modern applications.

In the UK, traditional charcoal production, once reliant on clamp and rings kilns, has evolved to more energy efficient retort methods, which yield more charcoal with less environmental impact. However, while the UK produces around 5,500 tonnes of charcoal annually, it still imports **95,000 tonnes from abroad**, primarily from tropical regions like Sub-Saharan Africa and Brazil, where charcoal production significantly contributes to deforestation. The WWF estimates that the EU's charcoal imports require 3.28 billion tonnes of timber, equivalent to **11 million hectares of forest**—nearly half a football pitch every second. With proper management and investment, the UK could meet up to 90% of its charcoal demand domestically, reducing reliance on unsustainable imports and making a major contribution to climate change mitigation.

In contrast to imports, locally produced charcoal in the UK offers a **90% reduction in carbon emissions**. A study by *Embercombe* found that producing one tonne of charcoal within the UK could save between 2.5 and 5.5 tonnes of CO2 equivalent emissions compared to imports. Given that the UK consumed 200,000 tonnes of charcoal in 2019, shifting to local production could remove the equivalent of 173,913 cars from the road each year.

UK made charcoal

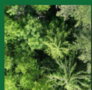
Globally, charcoal remains a critical commodity, with Sub-Saharan Africa accounting for 65% of global production and 950 million people relying on it as a primary cooking fuel. By 2050, demand for charcoal in Africa is projected to reach 1.67 billion tonnes, driven by its affordability compared to electricity and gas. This global reliance highlights the urgent need for sustainable production methods to mitigate the environmental impacts of deforestation. Expanding local charcoal production not only reduces carbon footprints but also creates opportunities for sustainable forest management and supports rural livelihoods, both in the UK and internationally.


charcoal maker's yard in Dorset

Building off the traditional production of charcoal, biochar has emerged as a modern, versatile alternative. While charcoal primarily focuses on maximizing energy output for industries, biochar's key value lies in its ability to stabilize carbon, locking it into the soil for **hundreds or even thousands of years.** This marks biochar as an increasingly essential tool for carbon dioxide removal (CDR) markets. As governments, corporations, and environmental organizations explore large-scale solutions to meet global carbon reduction targets, biochar is gaining momentum as a robust and scalable solution within the carbon and biodiversity marketplace.

According to the National Academy of Sciences, achieving the Paris Agreement's goals requires scaling up to 10 gigatons (Gt) of carbon removal annually by 2050, and biochar is poised to play a key role in this effort. By 2030, it is estimated that between 0.8 to 2.9 gigatons of global CO2 per year in removals capacity will be needed—up to **ten times the current output.**

This positions biochar as a critical and scalable solution within the CDR industry, which is estimated to grow to $1.2 trillion by 2050. Biochar alone could account for **$30-120 billion** of this market. In 2023, biochar accounted for 7% of total CDR purchases, but contributed **92.9% of CDR deliveries for the year**, signaling its prominence as a viable and immediate carbon removal strategy. As the market continues to expand and costs decrease, biochar is expected to become an indispensable tool in the global fight against climate change. By using biochar, countries like the UK can turn their agricultural and forestry biomass residues into carbon sinks while simultaneously improving soil quality and promoting ecological health.



Within this climate socio-economic paradigm, we can see a dynamic emerge that incentivizes responsible forestry management paired with rural stewardship modalities that support regenerative timber extraction. With a growing carbon removal market fueled by the most immediate and effective CDR technology—biochar—this roadmap offers a viable track for regenerating UK woodlands. If fragmented woodlands and landowners can pool their resources, they have the potential to create a more cohesive and efficient network for biochar, charcoal, and timber production services. Such a collaboration would allow smaller, disconnected plots of woodland to collectively scale their output, making use of underutilized biomass, while increasing overall land productivity. This would provide not only environmental benefits but also economic value, bringing communities back into the woods and increasing timber stock through improved land management.

ring kiln for charcoal production

Intelligence emerges from relationships: a set of simple interactions within a collectivity of elements can bring out properties that the individual components of the system alone did not possess. Intelligence may then be considered an emergent property of those systems.

FLOW.

From the forest to the final product, it's crucial to engineer a flow of materials, labor, and carbon that harmonizes with the needs of the forest and our planet. A systems-based approach can help us envision a robust nature-based infrastructure that incentivizes and supports emerging models of responsible forestry and regenerative timber products.

I propose a method for natural carbon harvesting that prioritizes the health of the forest ecosystem and locks away carbon for the long term in durable goods. Within this system, landowners, woodland stewards, and the construction industry will play vital roles in supporting a new economey centered around regenerative ecology.

NATURAL CARBON HARVESTING IN DESIGN

Lets turn our attention to the possible futures of material supply chains and waste streams that are designed for natural carbon harvesting. The Forest Commons Network proposes a collaborative system where individual landowners and forest managers come together to harness the potential of their woodland resources. Within this network, byproducts of sustainable forestry practices—such as branches, limbs, and offcuts of hardwoods—are transformed through minimal processing into high-value products for use in construction, furniture, and carbon sequestration. This approach prioritizes regenerative eco-social practices that not only manage forests for carbon storage but also produce tangible, functional outcomes that support a circular economy - supported by the burgeoning global carbon credit marketplace.

This strategy is built on integrated woodland management, viewing forests as components of a larger interconnected system of habitat corridors, canopy

sweet chestnut harvest

coverage, and biodiverse ecosystems. By bringing small, fragmented woodlands back into active management, the Forest Commons Network enhances biodiversity and fosters sustainable timber production, aligning ecological health with rural economic resilience. The **BRANCH. Methodology** offers a framework for achieving these goals, creating a direct, visible connection between the final product and the forest from which it originates—embodying the philosophy that design and production can align with nature's regenerative cycles.

As we shift from extractive models to more imaginative and generative interactions with the Earth, we can engage with Indigenous and ancestral land-based wisdom, embracing a paradigm shift toward stewardship and sustainability. This transition not only ensures ecological resilience but also fosters a deeper relationship with the land, enabling us to honor and integrate ancient knowledge with modern ecological solutions.

A CASE STUDY

This case study explores the transformation of a 10-hectare property in Dorset into a carbon harvesting and biodiversity enhancement project. The property is dominated by conifer species like Scots pine and Sitka spruce, covering about 60% of the area. The project aims to transition the woodland to a broadleaf-dominant ecosystem, introducing species such as oak, sweet chestnut, birch, and hazel. Four hectares will be dedicated to sweet chestnut, managed as coppice woodland for its fast growth and timber value, while the remaining six hectares will include a mix of oak, birch, and hazel to enhance carbon capture and support a diverse understorey for bird and insect habitat.

The phased approach will involve selectively thinning the existing conifers and gradually planting native broadleaf saplings. By integrating different species, growth rates, and the coppicing, the project aims to establish a resilient woodland structure, optimizing both ecological benefits and carbon revenue potential.

YEAR 0

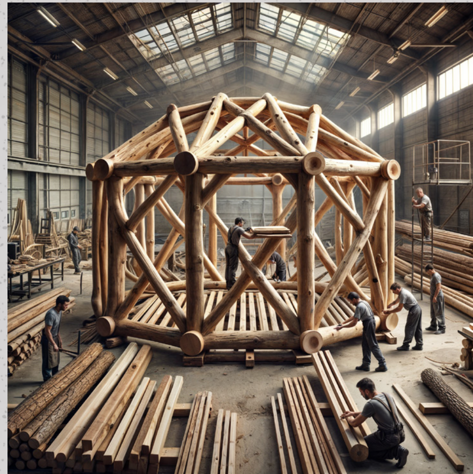
Many UK woodlands suffer from mismanagement due to years of neglect. Restoration begins by felling overgrown forest compartments to allow sunlight to reach the forest floor. Trees intended for coppicing are cut at the base, or stools, as part of a "coppice and stand" approach—combining coppice woodlands with larger standing trees. This habitat diversity creates a gradient of ecosystems that support species regeneration. All felled timber willl be utilized in long-lasting carbon products, such as timber structures, furniture, or biochar.

YEAR 1-10

Over the first 10 years, new growth will establish itself on the forest floor, with wildflowers emerging to attract insects and the birds that feed on them. Periodic, targeted felling will occur as the forest evolves into a more variant and vibrant ecosystem. During this period, many out-of-rotation hardwoods will mature, producing high-quality timber, often sourced from large branches. Felling during the winter months ensures that trees are lighter, as growth and water intake naturally slow during this time.

YEAR 10-20+

Sweet chestnut will reach maturity at year 10, ready for its first harvest cycle, yielding on average of 10-15 cubic meters of timber annually, depending on site conditions and management practices. In parallel, the mixed woodland of oak, birch, spruce after 20 years of growth, will yield a steady output. The oak, with its slower growth rate, will begin to provide high-quality hardwood for premium uses, while the faster-growing birch will contribute smaller but useful timber, suitable for biochar production and lighter construction applications.



CARBON HARVESTING

After 20 years, the timber harvested will vary in size and use:

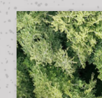
• Sweet Chestnut: Mature logs will measure around 15-25 cm in diameter. These logs are ideal for use in framing, outdoor structures, and cladding due to their natural durability and resistance to decay.

• Oak: The oak trees, with slower growth rates, will produce logs ranging from 20-30 cm in diameter. This high-quality hardwood is well-suited for beams,

flooring, and premium furniture

- Birch: The faster-growing birch trees will yield smaller logs, typically around 10-15 cm in diameter. These are suitable for lighter construction applications and also for biochar production, maximizing the utility of each harvest.
- Branches: Diameter of 5-10 cm— processed for biochar or used for structural components projects depending of shape and size.

Alongside timber production, charcoal and biochar will be generated from residual biomass and smaller timber products. Periodic harvests of sweet chestnut, including the processing of smaller branches, offcuts, and non-timber portions, are projected to yield approximately 200-250 tons of biochar. Over the 20-year period, the birch and oak woodlands are expected to produce an additional 150-200 tons of biochar. In total, the project aims to generate between **350-450 tons**, effectively utilizing the woodland's biomass and waste materials from processing, while maximizing carbon sequestration.



In the UK, carbon credits for biochar can vary but generally average around £70-100 per ton. Assuming the project produces 350-450 tons of biochar over 20 years:

At the lower estimate of 350 tons:

350 tons × £70/ton = £24,500

At the upper estimate of 450 tons:

450 tons × £70/ton = £31,500

Smaller projects like a 10-hectare woodland restoration can qualify for biodiversity credits on the voluntary market, where values range between £11,000 and £20,000 per unit, depending on the quality of the habitat improvement and certification requirements.

At the lower estimate of 5 biodiversity units:

5 units × £11,000/unit = £55,000

At the upper estimate of 10 biodiversity units:

10 units × £11,000/unit = £110,000

*5 units: Represents modest improvements, like increased vegetation diversity and soil health enhancements.

*10 units: Indicates more substantial gains, such as greater ecological complexity and diverse habitat features.

Total Revenue: £55,000 - £200,000
Annual Payment: £2,750 - £10,000 per year

FLOW.

This case study does not provide an exact prediction of the metrics achievable or revenue possible when restoring derelict or degraded woodlands in the UK; rather, it presents an aspirational vision of what is possible. The carbon and biodiversity markets vary widely in price and application, but one thing remains consistent: these markets are expanding rapidly and offer the most viable path for small woodland owners to be incentivized to implement regenerative land managements schemes like the BRANCH. methodology. Under this approach, it is possible to secure the necessary funding to improve the land and shift away from traditional timber production cycles, promoting a more sustainable future for woodlands.

LIFE CYCLE ANALYSIS

BRANCH Methodology

A focuses on sustainable woodland management and carbon sequestration through durable timber use and biochar production:

Biochar Sequestration: 1,050 - 1,350 tons of CO2 over 20 years.

Timber Sequestration: 100 tons of CO2 stored in durable products like furniture and construction materials.

Local Charcoal Use: Avoids 100 tons of CO2 by replacing imported charcoal.

Carbon Footprint: -1,250 - 1,550 tons of CO^2

Traditional Plantation Forestry

Prioritizes fast-growing, softwood species with less emphasis on sustainable practices:

Timber Sequestration: 75 tons of CO2 stored, but a lower percentage is used in long-term products.

Charcoal Emissions: Importing 100 tons of African charcoal results in 450 tons of CO2 emissions due to deforestation and transport.

Carbon Footprint: +375 tons of CO^2

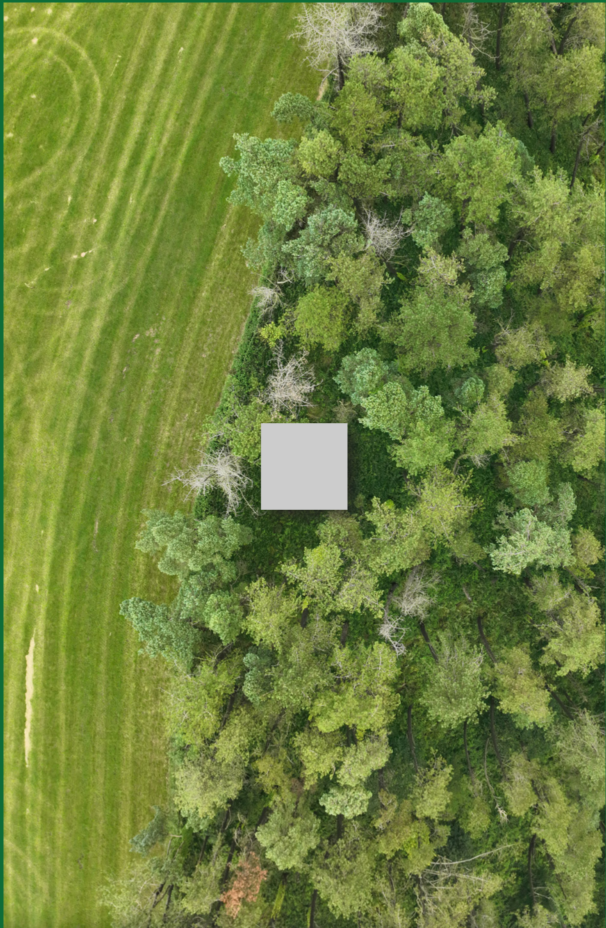
Who must agree to live in fictions that someone else wrote, and who has the power to write fictions for the rest of us? And if anyone can write fictions, why can't we write new ones?

FUTURE.

FUTURE.

The original objectives of the **BRANCH. Methodology** were to explore how small-diameter timber and forest residues could be effectively repurposed to advance sustainable architecture while supporting the health of woodland ecosystems. These goals were realized through a combination of fieldwork, digital scanning, and experimental design, culminating in a publication that highlights the potential of regenerative forestry practices. The research provided practical examples of integrating these materials into construction and established a framework for reorienting forestry practices toward ecological restoration and sustainable timber harvesting, bridging the gap between architecture, forestry, and environmental stewardship.

My research integrated advancements and findings across several specialized fields, including artificial intelligence, digital scanning technologies, sustainable forestry practices, carbon accounting systems, timber engineering, carbon markets, and biochar/charcoal production methods. The objective was to create a



cohesive methodology that could be utilized by architects, foresters, landowners, craftspeople, and the public. As part of this work, I conducted a two-week residency at Hooke Park, where I completed a comprehensive aerial scan of its 150-hectare woodland. I interviewed experts in coppicing, forest management, and charcoal production across the UK and contributed an outreach piece to the National Coppice Federation's quarterly newsletter. Utilizing an open-source tree segmentation program, I calculated woody biomass extraction based on compiled forest digital scan data. This research required me to take on multiple roles while leveraging the expertise and creativity of others to bridge knowledge gaps.

The methodologies and insights gained through this project contribute meaningfully to the architectural community by envisioning novel and replicable models for integrating woodland management and sustainable construction. This work promotes a paradigm where ecological balance, material efficiency, and cultural engagement are central to the practice. Thanks to the **RIBA Research Fund's** support, I will continue to develop this craft, expand its outcomes, and refine the processes that support it.

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GLOSSARY

- **Biochar**: A stable form of carbon produced by burning organic matter (biomass) in a low-oxygen environment, known as pyrolysis. It is used as a soil amendment to enhance soil fertility, improve water retention, and sequester carbon over long periods.
- **BRANCH. Methodology**: A sustainable forestry and land management approach that integrates ecological restoration, sustainable timber harvesting, and carbon accounting practices. It aims to promote biodiversity, enhance carbon storage, and provide economic opportunities through the regenerative use of small-diameter timber and forest residues.
- **CDR Markets**: Economic platforms that facilitate the trading of carbon credits generated through carbon dioxide removal (CDR) projects. such as reforestation, biochar, and direct air capture, to offset their carbon emissions and meet regulatory or voluntary climate targets.
- **Charcoal**: A form of carbon obtained by heating wood or other organic materials in the absence of oxygen. It is commonly used as fuel, but in forestry and land management, it can also be used for soil enrichment and carbon sequestration when produced sustainably.
- **Coniferization**: The process of converting or planting broadleaf or mixed forests with conifer species.
- **Continuous Cover Forestry (CCF)**: A forest management practice that maintains continuous tree cover over time. It involves selective harvesting and the promotion of natural regeneration to preserve forest structure, biodiversity, and ecosystem functions while allowing for ongoing timber production.
- **Coppice**: A traditional woodland management technique where trees are periodically cut down to their base to encourage new growth.
- **DBH (Diameter at Breast Height)**: A standard measurement of a tree's diameter taken at 1.3 meters (about 4.5 feet) above the ground.
- **Ecological Corridors**: Natural or semi-natural areas

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that connect different habitats, allowing wildlife to move freely between them.

- **Forest Commons Network**: An initiative or organization that supports the shared management and stewardship of forests, advocating for sustainable practices, community engagement, and the protection of forest ecosystems.
- **Hopps Foot**: A traditional unit of measurement used in forestry, particularly in the UK, referring to the length of wood (usually about 12 feet). It is used for estimating the volume and value of timber produced from managed woodlands.
- **Pollard**: A tree management technique where the upper branches of a tree are cut back to promote new growth from the top.
- **Terrestrial and Aerial LiDAR Scanning**: Techniques using light detection and ranging (LiDAR) technology to create detailed, three-dimensional models of landscapes and forests. Terrestrial LiDAR is conducted from the ground, while aerial LiDAR is performed using drones or aircraft.
- **Tree Migration**: The movement or assisted relocation of tree species to new areas in response to changing climatic conditions.

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