Clo Carbon Cymru

Dynamic Woodland Management for Ecology and Carbon:

Integrating Coppice Systems with Biochar-Based Carbon Sequestration in Welsh Broadleaf Woodlands

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Abstract

Wales faces two interconnected woodland challenges: widespread ecological decline and the urgent need for durable biogenic carbon sequestration to meet climate targets. Coppicing and pollarding (once central to Welsh woodland culture) provide an integrated solution to both.

These long-established practices create structural diversity, enhance habitat heterogeneity, and sustain long-term woodland continuity. When combined with on-site conversion of harvested biomass into biochar, these systems can generate up to 8 t CO_2e ha^{-1} yr^{-1} of permanent carbon removals.

This paper synthesises ecological evidence, cultural history, and contemporary carbon science to demonstrate why coppicing and pollarding are uniquely suited to Welsh woodlands. It shows how these traditional systems outperform modern management approaches, including Continuous Cover Forestry, High Forest systems, and 'singling', in delivering both ecological resilience and durable carbon sequestration. The result is a compelling case for restoring active coppice management as the foundation for woodland recovery and climate mitigation in Wales.

Foreword: Terminology and Definitions

This paper follows the terminological framework established by the late Professor Oliver Rackham in *The History of the Countryside (1986)*, which provides essential distinctions between different categories of tree-covered land:

Woodland: Land on which trees have arisen naturally and are managed through the art of **woodmanship** to yield successive crops. When woodland trees are cut down, they replace themselves through natural regeneration — coppice regrowth, suckering, or seedling establishment. Woodlands are self-sustaining ecological systems shaped by management, not dependent upon it for continuity.

Wood-Pasture: A land-use system involving the coexistence of grazing animals and trees, requiring active management (often through pollarding) to maintain tree cover while supporting pastoral activities.

Plantation: Land on which trees have been artificially established through planting, typically as monocultures or simplified assemblages. Plantations do not maintain themselves; when felled, they require replanting to sustain tree cover.

Forest (capitalised): A medieval legal designation referring to land on which the Crown or magnates held exclusive rights to keep and hunt deer. The term has no ecological meaning in this context.

These definitions are used consistently throughout this paper to distinguish between fundamentally different land-use systems with distinct ecological characteristics, management requirements, and carbon dynamics.

Plantation Forestry (not Woodland)

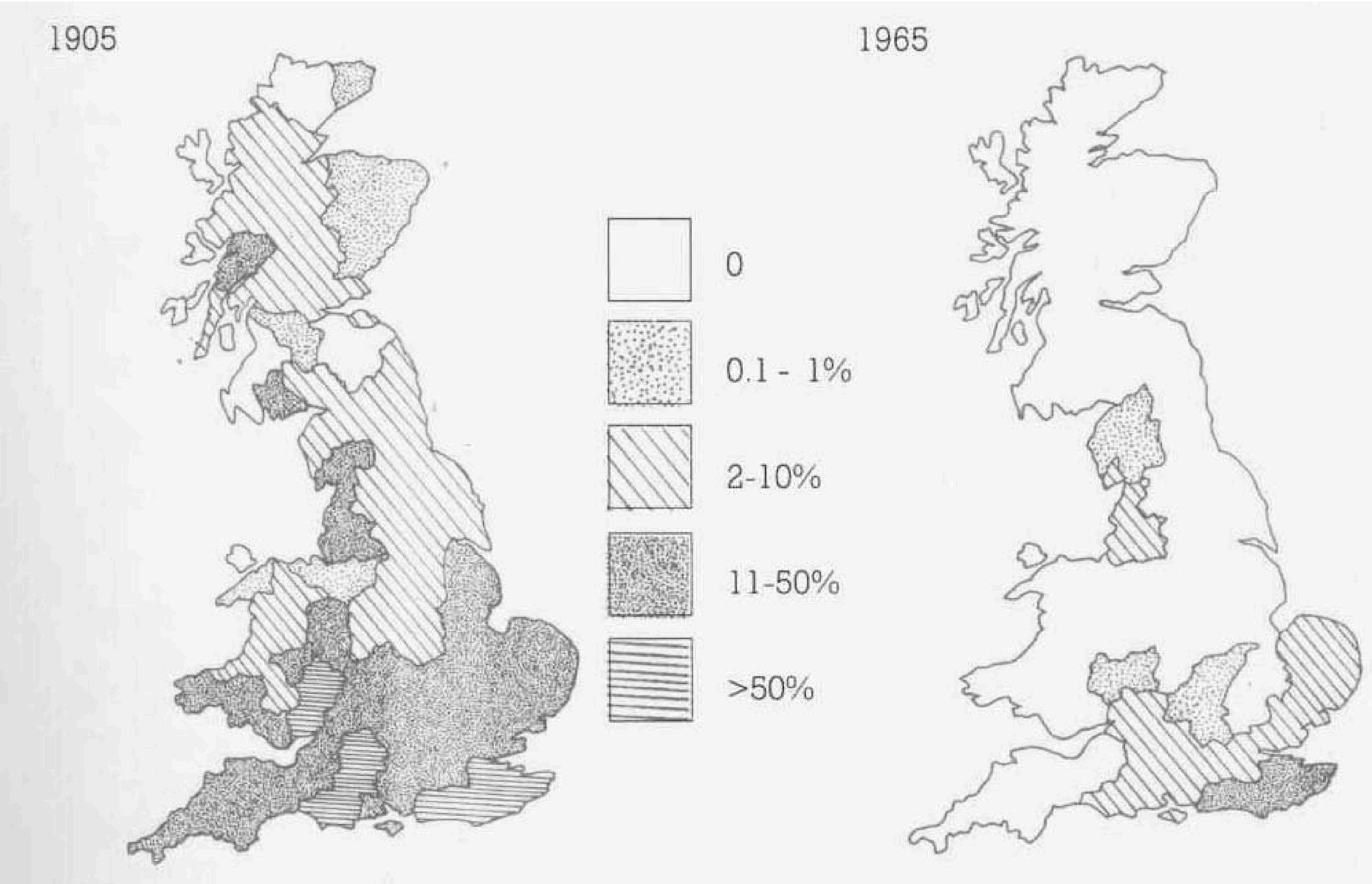

Figure 1. Distribution of actively coppiced woodland in Britain, showing the contraction of coppice towards the south-east during the 20th century. The area of coppice in each county is shown as the percentage of the total woodland area in 1905 (after Peterken 1981). The Forestry Commission was established in 1919.

The art of woodmanship, central to Rackham's understanding of woodland management, refers to the body of practical knowledge acquired through sustained engagement with self-renewing broadleaf systems — distinct from the plantation-focused silviculture that has dominated forestry policy in Wales since the Forestry Commission's establishment in 1919. The Commission's intensive conifer planting programmes in Wales and Scotland during the 20th century both reflected and reinforced an institutional preference for plantation management over traditional woodland systems.

Notably, areas of England where large-scale conifer afforestation did not occur — particularly the southern counties — have retained both active coppice practice and the transmission of woodmanship skills, underscoring the connection between landscape-scale policy choices and the erosion or persistence of knowledge systems.

Introduction

Native broadleaved woodlands in Wales are in crisis. Although 91% are categorised as being in 'intermediate condition', detailed indicators reveal a stark reality: 98% lack sufficient veteran trees; 84% have inadequate open space; and 82% fall short on natural deadwood volumes. These deficits reflect a deeper structural decline: a loss of the dynamic processes that historically sustained biodiversity (*Woodland Trust, 2025*).

Modern management approaches, including high forest systems and continuous cover forestry (CCF), emphasise canopy retention but not the structural dynamism essential to woodland health. Coppicing and pollarding, by contrast, are cyclical systems rooted in Welsh history (*Linnard, 2000*). They create rotating mosaics of light and shade, maintain multi-generational continuity, and support species-rich flora and fauna absent from closed-canopy stands. Long-established broadleaf woodlands have demonstrated remarkable structural and ecological stability under active management, particularly where rotational cutting systems such as coppicing were historically maintained (*Rackham, 2003; Thomas et al., 2011*).

Wales contains approximately 42,000 hectares of ancient semi-natural woodland (ASNW), defined by continuous tree cover since at least 1600 AD and the long-term retention of native woodland characteristics.

In total, ancient woodland covers around 95,000 hectares, although much of this comprises Plantations on Ancient Woodland Sites (PAWS), where conifers were established over former native woodland. The wider broadleaf woodland resource extends to approximately 173,000 hectares, including ASNW, secondary native woodland, and broadleaf components within restoration sites (*Forest Research, 2024*).

Collectively, these woodlands (particularly former coppice sites and secondary broadleaf stands) represent a substantial resource with strong potential for the reintroduction of active coppice management. The vast majority of this broadleaf resource (approximately 85%, or 147,000 hectares) is privately owned, with only 26,000 hectares managed by Natural Resources Wales. Much of this privately held woodland is under-managed or unmanaged, contributing little to farm income while failing to deliver meaningful carbon sequestration or ecological benefits.

For landowners and farmers, woodland parcels often represent marginal land that generates minimal economic return under current management paradigms. The integration of coppicing with biochar production offers a pathway to transform these underperforming assets into productive systems capable of generating regular income through verified carbon removals, while simultaneously restoring ecological function and cultural continuity.

Coppicing, Carbon Removal and Woodland Policy in Wales

The perception of coppicing as economically marginal continues to influence decision-making across Wales. This perception is rooted in historical shifts in energy use, materials and labour, and in valuation frameworks that favour long-rotation, high-volume timber production. As a result, many native broadleaf woodlands that were formerly managed as coppice are now under-managed, structurally simplified, or treated primarily as passive carbon stores. This reflects not an absence of productivity, but a mismatch between coppicing's outputs and traditional economic assessment models.

Recent developments in high-integrity, nature-based carbon removal markets (particularly those based on biochar production) materially alter this assessment. Coppice systems generate regular, renewable supplies of small-diameter biomass well suited to biochar production, converting material of historically low market value into durable, verifiable carbon storage.

Microsoft is actively investing in biochar as a high-integrity Carbon Dioxide Removal (CDR) pathway to help meet its corporate climate goals, including becoming carbon negative by 2030 and removing its historical emissions by 2050. The company has entered multiple purchase agreements to secure durable, verifiable biochar carbon removal credits. Notably, a decade-long deal with Exomad Green aims to remove at least 1.24 million tonnes of CO_2 via biochar, tracked and certified with independent digital Monitoring, Reporting, and Verification (dMRV) systems to ensure transparency and permanence (*Biochar Today, 2025*).

[Biochar: A carbon removal solution gaining ground]

Where biochar achieves high fixed-carbon content and is embedded in recognised certification frameworks, this provides a credible mechanism for aligning active woodland management with climate mitigation objectives. In this context, coppicing becomes economically viable not as a niche practice, but as a management system capable of delivering measurable climate outcomes alongside biodiversity, soil health and landscape benefits.

From a policy perspective, this model aligns closely with Welsh priorities for the Sustainable Management of Natural Resources, nature recovery and long-term resilience. Reinstating coppice management can enhance structural diversity, support priority species, and maintain ecological continuity within native broadleaf woodlands, while avoiding the ecological trade-offs associated with clear-fell systems or inappropriate afforestation. For farmers and woodland owners, coppicing linked to local biochar production offers the potential for diversified income streams compatible with mixed land use, smaller woodland parcels and community-scale enterprise.

While coppicing will not be economically viable in all circumstances, biochar-based carbon removal provides a pathway by which its value can be assessed against contemporary policy objectives rather than historic market limitations. For Natural Resources Wales (NRW), local authorities and land managers, this suggests a role for coppice not as a legacy practice, but as a practical, policy-relevant tool for delivering climate, nature and rural development outcomes in Wales.

This economic shift enables a fundamental reframing of woodland carbon management. **Where conventional approaches treat standing biomass as the primary carbon store, coppicing integrated with biochar production recognises that managed woodlands cycling carbon through durable storage pathways can outperform passive systems over climate-relevant timescales.**

Carbon held in mature trees is inevitably returned to the atmosphere through decay, disease, windthrow, or eventual harvest, typically within decades to a century. In contrast, biochar derived from coppice biomass achieves residence times of 100–1,000 years when incorporated into soils or used in appropriate applications. For landowners and policymakers focused on durable climate outcomes, this suggests that **regular, planned harvesting of existing broadleaf woodlands may deliver greater verified carbon removals than planting new trees and waiting for them to mature** — a conclusion that directly challenges the tree-planting narrative that dominates Welsh climate policy.

Ecological Foundations of Coppicing and Pollarding

Structural Diversity and Ground Flora: Coppicing opens the canopy in small rotational coupes (0.1–0.5 ha). These temporary glades allow light-demanding species (woodland herbs, butterflies, bees, bryophytes, and specialist invertebrates) to thrive (*Rackham, 1980; Woodland Trust, 2022*). As the canopy gradually recloses, conditions shift, maintaining a dynamic mosaic across the woodland. This cyclical disturbance pattern is the ecological heartbeat missing from many contemporary Welsh management systems.

Tree Longevity and Continuity: Repeated cutting reduces the risk of mechanical failure, allowing stools to persist for centuries (*Rackham, 2003*). Pollarded trees, raised above browsing height, can be even longer-lived. This contradicts the misconception that felling interrupts woodland continuity. In reality, traditional coppice and pollard systems create deep temporal resilience.

Cultural and Historic Foundations: Welsh woodlands historically relied on short-rotation 'underwood' to supply charcoal, fuel, and rural industries. These systems inadvertently created highly biodiverse habitats long before modern conservation existed (*Linnard, 2000*). Reviving these practices reconnects management with cultural heritage and ecological authenticity.

Carbon Dynamics and Biochar Integration

Carbon Dynamics in Broadleaf Woodlands: Mature broadleaf stands typically sequester around 1.2 t C ha^{-1} yr^{-1} (approximately 4.4 t CO_2e) (*Thomas et al., 2011*). Newly planted trees require decades to reach these rates and may lose soil carbon during establishment (*Poeplau & Don, 2013*). Afforestation does not necessarily deliver immediate or sustained net carbon gains, particularly where soil carbon losses and long establishment periods offset above-ground biomass accumulation (*Poeplau & Don, 2013; Matthews et al., 2020*).

Coppicing maintains:

- intact root systems and minimal soil disturbance
- rapid regrowth (up to 5–10 t dry matter ha^{-1} yr^{-1}; *Evans, 1992*)
- continuous net primary productivity

However, traditional coppice cycles and many associated craft products (wattle hurdles, thatching spars, etc.) return most of the harvested carbon back to the atmosphere. To transform ecological management into climate mitigation, harvested material must enter a stable carbon pool: **biochar.**

Coppicing, Pollarding, and Biochar: Process Overview

- Regular coppicing/pollarding generates predictable biomass
- On-site pyrolysis converts material into biochar with minimal transport emissions
- Biochar application/storage secures long-term carbon removal

Carbon Accounting: Using realistic Welsh broadleaf productivity:

- Biomass regrowth: approximately 8 t DM ha^{-1} yr^{-1}
- Biochar yield: approximately 30% → 2.4 t
- Carbon content: 90% → 2.16 t C
- CO_2 equivalent: 2.16 × (44/12) = approximately 7.9 t CO_2e ha^{-1} yr^{-1}

Thus, coppice + biochar systems can deliver approximately 8 t CO_2e per hectare per year of durable removals, many times higher than traditional afforestation during the first 20–30 years.

Policy Context: Understanding Current Welsh Woodland Management

The dominance of particular woodland management systems in Wales reflects not ecological optimisation, but a convergence of policy targets, institutional incentives, and long-standing assumptions about how broadleaved woodlands should contribute to climate mitigation and land management. Across Welsh Government, Natural Resources Wales and major non-governmental actors, woodland strategy has become increasingly defined by planting-led metrics, with insufficient attention being given to long-term management, carbon permanence, and climate resilience.

Welsh Government policy has set ambitious net-zero pathways that include the creation of 180,000 hectares of new woodland by 2050, framing woodland expansion as a central climate solution. While these targets have helped mobilise political momentum and funding, they have also embedded a quantitative bias into woodland policy, where success is measured primarily in hectares planted rather than in ecological function or verified carbon outcomes. This framing risks conflating woodland creation with climate effectiveness, despite growing evidence that planting alone does not guarantee durable carbon sequestration or resilience under climate change.

Natural Resources Wales, as both regulator and land manager, has played a key role in operationalising this approach. Through grant guidance, advisory services, and the management of the Welsh public forest estate, NRW has largely aligned with low-intervention and establishment-focused woodland models. Although climate adaptation and biodiversity are acknowledged in principle, management systems that involve regular cutting (such as coppicing and pollarding) remain marginal within official guidance and practice.

This reflects an institutional preference for approaches that minimise visible intervention and administrative complexity. These preferences are further reinforced by the predominance of conifer-focused forestry training within the sector, which emphasises desk-based planning and timber production over the practical art of woodmanship — skills that can only be acquired through sustained, hands-on engagement with broadleaved woodland systems.

Non-governmental organisations, particularly the Woodland Trust, have further reinforced this policy environment through highly effective public-facing campaigns centred on tree planting and the principle of '*the right tree in the right place*'. While this framing rightly emphasises species choice and site suitability, it does not meaningfully address how woodlands should be managed over time to deliver durable carbon removals or withstand accelerating climate stress. The Trust's policy documents acknowledge climate change, yet appear to remain largely silent on the role of intensive, regenerative management systems such as coppicing and pollarding.

Recent experience highlights the risks of this approach. Across Wales and the wider UK, large-scale planting schemes have experienced high rates of sapling failure linked to drought and extreme weather, exposing the vulnerability of establishment-led strategies. At the same time, ecological assessments continue to show that increases in woodland cover have not translated into commensurate improvements in woodland condition, with many sites characterised by simplified structure and limited age diversity.

Coppicing and pollarding have often been dismissed as economically obsolete, largely because traditional markets for small roundwood have declined. However, the emergence of high-integrity carbon removal mechanisms fundamentally changes this assessment. By enabling the conversion of harvested biomass into stable carbon stores through biochar, these systems deliver verifiable, long-term climate benefits while enhancing ecological resilience.

In this context, the marginalisation of coppicing and pollarding is best understood as a consequence of institutional inertia rather than limitation. Addressing climate breakdown will require Welsh woodland policy to move beyond planting targets and toward management systems explicitly designed to deliver resilience, biodiversity recovery, and durable carbon sequestration over centuries rather than decades.

Comparing Coppice and Pollard Systems with Current Management Approaches

High Forest Systems dominate much of the contemporary woodland landscape in Wales, particularly in broadleaf stands that were historically managed as coppice. These systems are often justified on the grounds of producing large-diameter timber, maintaining continuous canopy cover, and minimising management intervention. However, their continued dominance reflects institutional preference rather than ecological or climatic performance.

From a carbon perspective, high forest systems prioritise biomass accumulation over time but fail to address carbon permanence and turnover. Carbon is retained in standing trees for extended periods, yet remains vulnerable to release through disease, drought, storm damage, or eventual harvesting. In a context of accelerating climate breakdown, this reliance on long-lived, unmanaged biomass represents a high-risk carbon strategy, particularly where structural uniformity limits resilience.

Ecologically, high forest systems suppress ground flora and structural diversity through prolonged canopy closure, leading to simplified habitats with reduced biodiversity. These outcomes are well documented, yet the system persists because it aligns neatly with planting-led narratives and requires little ongoing management. In effect, high forest systems externalise ecological and climatic risk while maintaining the appearance of stability.

Continuous Cover Forestry (CCF) has been promoted in Wales as an ecologically sensitive alternative to clearfell systems, emphasising canopy retention, uneven-aged stand structures, and reduced visual disturbance. While these attributes may offer some localised benefits, particularly in landscapes where clearfelling has provoked public opposition, CCF remains poorly aligned with both ecological restoration goals and long-term carbon sequestration under conditions of climate change.

In practice, CCF systems in Welsh broadleaf woodlands frequently result in prolonged canopy closure, suppressed regeneration, and limited structural diversity at ground and shrub layers. The absence of regular disturbance reduces the availability of light-dependent niches, leading to declines in woodland ground flora, invertebrates, and early-successional species. From an ecological perspective, these outcomes closely resemble those of high forest systems, differing primarily in visual presentation rather than functional performance.

From a carbon perspective, CCF compounds the vulnerabilities already identified in high forest systems while adding limited compensatory benefits. Although proponents argue that uneven-aged structures enhance resilience, CCF's emphasis on canopy retention means that carbon remains concentrated in standing biomass rather than being transferred into more durable pools. The periodic selective harvesting characteristic of CCF does create some opportunities for biomass removal, yet in practice this material is typically directed toward conventional timber markets, local firewood markets or left to decay in situ, rather than being converted into stable carbon forms.

Where high forest systems at least accumulate biomass predictably, CCF's selective interventions disrupt productivity without enabling systematic carbon transfer to durable storage. The result is a management approach that retains the carbon vulnerability of passive systems while requiring ongoing administrative oversight and skilled implementation — costs that deliver neither enhanced permanence nor improved ecological outcomes.

The persistence of CCF within Welsh woodland policy reflects its compatibility with existing governance structures, funding mechanisms, and public narratives of 'low-impact' forestry, rather than demonstrable advantages in ecological resilience or carbon permanence.

Singling / Stored Coppice, or the conversion of coppice stools into single-stem 'standards', has frequently been promoted as a compromise between historical coppice management and modern forestry objectives. This approach is typically presented as a means of improving timber quality while retaining some continuity with traditional woodland structure. However, in practice, singling represents a loss of both ecological function and management efficiency.

By reducing multi-stem stools to single stems, singling undermines the regenerative capacity that makes coppicing resilient to disturbance and climatic variability. The resulting trees often develop poor form and limited timber value, while the woodland loses the cyclical light conditions essential for diverse ground flora. Carbon dynamics are similarly weakened: biomass accumulation slows, harvesting becomes infrequent, and opportunities for durable carbon sequestration through biochar are foreclosed.

Singling persists largely because it avoids the political and cultural discomfort associated with regular cutting. It allows woodlands to appear 'managed' without confronting the deeper structural changes required to align woodland systems with climate realities. As such, it exemplifies a policy tendency where systems are maintained because they are socially acceptable, not because they are effective.

Why Coppicing and Pollarding Outperform These Models

Coppicing and pollarding outperform high forest, CCF, and singling systems precisely because they address the root failures embedded in contemporary woodland policy. Ecologically, rotational cutting creates a dynamic mosaic of light conditions, supporting rich ground flora, invertebrate communities, and trophic complexity. Structurally, multi-stem regeneration enhances resilience to drought, windthrow, and disease (risks that are intensifying under climate change). Culturally, coppicing and pollarding reconnect woodlands with long-standing land-use traditions that were explicitly designed for continuity under uncertainty.

From a carbon perspective, the integration of coppicing or pollarding with on-site biochar production fundamentally alters the equation. By converting a proportion of harvested biomass into stable carbon forms with residence times measured in centuries, these systems deliver non-reversible biogenic carbon storage rather than temporary storage. The emergence of permanence-compliant carbon removal certificates further reinforces their viability, decoupling woodland value from declining material markets and embedding carbon integrity directly into management practice.

In contrast to planting-led approaches, coppicing and pollarding recognise that climate resilience and carbon efficiency depend on management, not tree numbers. Their continued marginalisation reflects institutional inertia rather than scientific limitation. As climate breakdown accelerates, these systems offer a rare convergence of ecological restoration, cultural continuity, and climate mitigation.

Recommended parameters for coppicing and pollarding systems in Welsh woodlands:

- Coppice coupes: 0.1–0.5 ha
- Coppicing rotations: 2–15 years (osier, poplar, hazel, ash, small oak)
- Standards: 10–20% retained
- Harvesting: winter to early spring
- Monitoring: flora surveys, stem vitality, coupe-age mapping

These practices produce reliable biomass for pyrolysis and maintain ecological heterogeneity.

Welsh Policy Alignment: From Tree Numbers to Management Outcomes

Current Welsh woodland policy is characterised by a strong emphasis on woodland creation targets, canopy cover, and long-term biomass accumulation, most notably through commitments to expand woodland area by approximately 180,000 hectares by 2050. While these ambitions are frequently framed as climate-positive, they remain weakly connected to questions of woodland function, management quality, and carbon durability.

This policy orientation has favoured management approaches that minimise visible intervention and administrative complexity, including high forest and continuous cover systems, even where such approaches underperform in terms of ecological dynamism and climate mitigation. The result is a governance environment in which establishment metrics and planting rates are privileged over long-term outcomes such as biodiversity recovery, regeneration capacity, and carbon permanence.

Aligning woodland policy with climate and biodiversity objectives therefore requires a shift away from area-based targets toward outcome-based frameworks that explicitly value management systems capable of operating under disturbance and uncertainty. Coppicing and pollarding, particularly when integrated with biochar-based carbon removal, align more closely with these requirements by embedding renewal, risk management, and verifiable carbon outcomes into woodland stewardship. Such a realignment would not entail abandoning woodland creation, but rather reframing it within a broader strategy that recognises active management as a necessary condition for ecological resilience and credible climate mitigation. Without this shift, Welsh woodland policy risks continuing to invest in systems that appear stable in the short term, yet remain poorly equipped to deliver durable benefits under accelerating environmental change.

Durable Carbon Removals and Permanence-Compliant Accounting

Current approaches to woodland carbon accounting in Wales remain poorly aligned with the realities of climate risk, ecological disturbance, and long-term land stewardship. Existing frameworks tend to treat carbon held in standing biomass as functionally equivalent to centuries-scale carbon sequestration, despite the fact that such carbon remains vulnerable to reversal through drought, disease, fire, windthrow, or future land-use change. This conflation obscures important differences in carbon durability, risk, and permanence, and limits the effectiveness of woodland-based climate policy.

Coppicing and pollarding systems, when integrated with biochar production, offer a fundamentally different carbon proposition. Rather than maximising short-term biomass accumulation, these systems enable a proportion of biogenic carbon to be transferred into stable forms with residence times measured in centuries. This shift reframes woodland management from temporary carbon storage toward verifiable, long-term carbon removal, consistent with emerging scientific and policy distinctions between emissions reduction, storage, and removal.

The relevance of this distinction is not merely technical. As climate impacts intensify, the probability of carbon loss from standing forests increases, undermining the credibility of mitigation strategies that rely solely on biomass retention. Carbon accounting frameworks that fail to incorporate permanence and reversal risk may overstate the climate contribution of planting-led or low-intervention forestry systems. In contrast, permanence-compliant approaches explicitly recognise and manage these risks, aligning accounting practice with climate reality.

This distinction has profound implications for woodland strategy. A hectare of actively coppiced broadleaf woodland producing biochar can deliver approximately 8 t CO_2e ha^{-1} yr^{-1} of verified, permanent carbon removal — substantially exceeding the sequestration rates of newly planted trees during their first 20-30 years, and delivering carbon storage that persist for centuries rather than decades. Where Wales has prioritised woodland expansion as its primary climate response, the carbon accounting presented here suggests that managing existing broadleaf resources through rotational cutting may represent a more effective use of limited land, labour, and capital. This is not to argue against appropriate afforestation, but to recognise that **where broadleaf woodlands already exist, cutting them down (coppicing and pollarding) and converting the biomass to biochar may be climatically preferable to other management prescriptions.**

The development of high-integrity carbon removal standards, including biochar-based certification schemes, provides a mechanism through which active woodland management can be credibly integrated into climate policy. These standards enable carbon outcomes to be quantified, verified, and valued based on durability rather than volume, allowing coppicing and pollarding systems to contribute meaningfully to net-zero strategies without relying on speculative long-term assumptions about woodland stability.

From a policy perspective, this represents a significant opportunity. By recognising durable carbon removals generated through managed woodland systems, Welsh Government can realign incentives away from establishment metrics and toward outcome-based climate performance. Such an approach supports ecological resilience, reduces exposure to carbon reversal, and embeds adaptive management within climate mitigation strategies.

Ultimately, the challenge for woodland carbon policy is not whether trees store carbon, but how long that carbon can be expected to remain sequestered under conditions of accelerating change. Management systems that explicitly address permanence, renewal, and risk are therefore better suited to long-term climate mitigation than those predicated on indefinite biomass retention. Reframing woodland carbon policy around durability rather than expansion is a necessary step toward credible, resilient climate action.

Economic, Cultural, and Institutional Renewal

Reframing woodland policy around active management has implications beyond carbon accounting. Coppicing and pollarding support local employment, skills development, and cultural continuity in ways that low-intervention forestry cannot. These systems historically underpinned rural economies precisely because they were designed to produce regular yields without degrading ecological function, a principle that is newly relevant under climate constraints.

However, realising these benefits requires confronting institutional barriers. Funding mechanisms that favour tree planting over long-term management, advisory systems oriented toward minimal intervention, and organisational models dependent on planting-based fundraising all act to suppress the adoption of regenerative management practices. Without addressing these structural constraints, policy will continue to reproduce the same underperforming systems.

The Welsh Government therefore faces a clear choice: continue to support woodland expansion strategies that prioritise visibility and short-term metrics, or invest in management-led systems capable of delivering biodiversity recovery, climate resilience, and durable carbon sequestration. The evidence presented in this paper suggests that only the latter pathway is compatible with the realities of climate breakdown and long-term ecological stewardship. Without a shift from planting-led policy to management-led outcomes, Welsh woodland strategy risks becoming an exercise in institutional reassurance rather than a credible response to climate breakdown.

Conclusion

This paper has argued that coppicing and pollarding, particularly when integrated with biochar production, offer a powerful and underutilised framework for restoring ecological function and delivering durable carbon sequestration in Welsh broadleaf woodlands. These systems outperform many contemporary management approaches not because they are novel, but because they are explicitly designed for renewal, resilience, and continuity under change (qualities that are increasingly essential under conditions of climate breakdown).

At the same time, it is important to state clearly that this analysis does not propose a universal prescription for woodland management in Wales. Welsh woodlands are not a homogeneous resource, and neither their histories nor their current ecological states are uniform. As Oliver Rackham repeatedly emphasised, many of the woodlands that survive today are cultural landscapes, shaped over centuries by deliberate human intervention rather than by passive natural processes (*Rackham, 1980; 2003*). Their ecological character, species composition, and structural diversity cannot be understood, or responsibly managed, without reference to that history.

George Peterken's work further underscores the need for caution and context. While coppicing has historically supported high levels of biodiversity in many ancient and semi-natural woodlands, Peterken also recognised that some long-neglected woods may now support alternative ecological equilibria, including species assemblages that could be disrupted by poorly considered re-intervention (*Peterken, 1981; 1996*). In such cases, conservation priorities must focus on protecting existing ecological value, and any change in management should be preceded by rigorous, site-specific assessment.

The argument advanced here is therefore selective and proportionate, not dogmatic. Coppicing and pollarding should be prioritised where they reflect historical practice, where structural simplification has reduced ecological function, and where management objectives include long-term resilience and verified carbon removal. They are particularly well suited to secondary broadleaf woodlands, former coppice sites, and landscapes where uniform canopy closure, regeneration failure, or loss of early-successional habitat has constrained biodiversity.

Crucially, the historical decline of coppicing should not be misinterpreted as evidence of ecological failure. As Julian Evans demonstrated, the marginalisation of coppice systems in Britain was driven primarily by economic and policy shifts (notably the collapse of markets for small roundwood and the institutional preference for high-forest models) rather than by shortcomings in ecological performance. These same structural forces continue to shape woodland policy today, reinforcing planting-led approaches and low-intervention management despite their limited effectiveness in delivering durable carbon sequestration or climate resilience.

What has changed is the wider context. Climate breakdown has exposed the fragility of systems that rely on long-term biomass accumulation without renewal, while the emergence of permanence-compliant carbon accounting (including biochar-based carbon removal certificates) has fundamentally altered the economic viability of active woodland management. In this new landscape, coppicing and pollarding are no longer constrained by declining material markets; instead, they can generate value directly through verifiable, long-term climate mitigation, while simultaneously restoring ecological complexity and cultural continuity.

Taken together, the insights of Rackham, Peterken, and Evans point toward a woodland policy that is historically informed, ecologically grounded, and functionally adaptive. Effective responses to climate breakdown will not be delivered through planting targets alone, nor through the assumption that minimal intervention equates to naturalness. Rather, they require management systems explicitly designed to operate under uncertainty, systems that recognise woodlands as living, dynamic entities whose value lies not simply in their extent, but in how they are stewarded over time. The integration of coppicing, pollarding and biochar represents a rare convergence of ecological restoration, cultural continuity and climate mitigation, warranting immediate policy consideration and pilot-scale implementation.

The central challenge this analysis presents to Welsh woodland policy is uncomfortable but unavoidable: **under current climate trajectories and carbon accounting frameworks, managing existing broadleaf woodlands through rotational cutting and biochar production removes more atmospheric carbon, more durably, than planting new trees and leaving them to grow.** This conclusion contradicts deeply embedded public narratives and institutional preferences, but it follows directly from the evidence on biochar permanence, soil carbon residence times, and the increasing vulnerability of standing biomass to climate-driven reversal.

The question facing Welsh Government, NRW, and conservation organisations is therefore not whether coppicing and pollarding represent viable management options, but whether Wales is prepared to align its climate policy with the scientific evidence on carbon durability rather than with the politically expedient metric of trees planted. **Climate breakdown does not permit the luxury of comfortable narratives; it demands woodland management systems that can be shown to work over centuries, not merely systems that look like they should work.**

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Annex A – Anticipated Critiques and Responses

This annex addresses common critiques likely to be raised by stakeholders within the forestry, conservation, and policy sectors in response to the arguments advanced in this paper. These responses are intended to clarify scope, evidence, and intent.

Critique 1: Coppicing and pollarding are outdated practices unsuited to modern woodland management.

Response: Coppicing and pollarding are not proposed here as nostalgic or traditional practices, but as functionally adaptive management systems designed to operate under long-term ecological uncertainty. Their historical persistence reflects their capacity to maintain productivity, structural diversity, and resilience over centuries, not their antiquity per se. As demonstrated by Evans (*1992*), their decline was driven primarily by market collapse and policy preference for high forest models, rather than by ecological or silvicultural failure. When integrated with contemporary biochar production and permanence-compliant carbon accounting, these systems represent a modern response to climate and biodiversity challenges, not a regression to pre-industrial forestry.

Critique 2: Tree planting and continuous canopy cover are essential for carbon sequestration.

Response: Tree planting and canopy retention can contribute to carbon storage, but this paper **distinguishes clearly between temporary carbon storage and durable carbon removal**. Carbon held in standing biomass remains vulnerable to reversal through disturbance, disease, drought, and future management decisions. Under accelerating climate change, these risks are increasing. Coppicing and pollarding systems integrated with biochar production allow a proportion of biogenic carbon to be transferred into stable pools with residence times measured in centuries, thereby delivering climate benefits that are more robust to disturbance and reversal. The argument is not that planting has no role, but that planting alone is insufficient as a climate mitigation strategy.

Critique 3: Coppicing would damage ancient woodlands and threaten existing biodiversity.

Response: The paper explicitly rejects a universal or prescriptive approach to woodland management. As emphasised by Rackham (1980, 2003) and Peterken (1981, 1996), ancient woodlands vary greatly in their management history and ecological condition. Some long-neglected ancient woods may now support biodiversity assemblages that could be disrupted by inappropriate intervention. In such cases, conservation objectives should prioritise protection and continuity. Coppicing and pollarding are therefore proposed as context-dependent tools, to be applied where historical precedent, ecological assessment, and management objectives align, not as blanket prescriptions.

Critique 4: Markets for coppice products no longer exist, making these systems economically unviable.

Response: This critique reflects an outdated framing of woodland value. While traditional markets for small roundwood have declined, the emergence of high-integrity carbon removal mechanisms fundamentally alters the economic basis of active woodland management. By generating verifiable, permanence-compliant durable carbon removals through biochar production, coppicing and pollarding systems can deliver economic value directly linked to climate mitigation outcomes. This decouples their viability from declining material markets and aligns woodland management with contemporary climate policy objectives.

Critique 5: The paper underestimates the role of organisations such as NRW and the Woodland Trust in promoting sustainable forestry.

Response: The analysis does not question the intent or commitment of public bodies or conservation organisations. Rather, it examines how institutional incentives, funding structures, and policy metrics shape management outcomes. Welsh Government, NRW, and major NGOs operate within a shared policy environment that prioritises woodland expansion and low-intervention approaches. The paper argues that this convergence has inadvertently marginalised management systems better suited to delivering resilience and durable carbon sequestration. The critique is therefore structural rather than organisational, and is intended to inform policy evolution rather than attribute blame.

Critique 6: This approach risks distracting from the urgent need to increase woodland cover.

Response: The paper does not argue against woodland creation where it is ecologically appropriate. However, it cautions against treating woodland expansion as a proxy for climate effectiveness. Without attention to long-term management, resilience, and carbon permanence, increases in woodland area risk delivering diminishing returns under climate stress. Reframing woodland policy to prioritise management outcomes alongside establishment is therefore not a distraction from climate action, but a necessary refinement of it.