

FEATURE

Heather Allen, Co-Founder and Trustee, The Carbon Community

CRUSHED ROCKS AND MICROBES

BOOST GROWTH AND CARBON STORAGE IN YOUNG PLANTINGS

With new woodlands central to the UK's climate and biodiversity targets, strong tree establishment and reliable carbon sequestration are critical. A large, long-term field experiment is showing that simple, practical interventions can give young forests a boost and help lock away more carbon.

The study evaluates two types of forest: a Welsh native broadleaf mix of alder (22%), aspen (5%), downy birch (35%), wild cherry (19%), sessile Oak (13%) and rowan (6%), and conifer areas of Sitka spruce. Credit: Paul Box

The Glandwr Forest Carbon Study provides rare, large scale experimental evidence that simple, nature-based interventions can materially change early carbon outcomes in new broadleaf woodlands.

New research published in the journal *Communications Sustainability* shows that simple, nature-based interventions can boost young tree growth in new broadleaf woodlands, increasing above-ground biomass by 13% to 27% in the first four years.

As lead author Dr Bonnie Waring, Associate Professor in Ecosystems Ecology, Imperial College London, explains: "What makes this study scientifically striking is not only the potential for carbon removal, but also its unprecedented scale, and the high level of citizen science involvement.

"We all need our new woodlands to thrive – for biodiversity, for our wellbeing and for our climate efforts in the UK and beyond. After just four years, we can demonstrate how each of these simple, nature-based interventions effectively supports the early years of tree establishment and the carbon uptake capacity of new woodlands."

The findings come from the first four years of the Glandwr Forest Carbon Study, an ongoing collaboration between science-based charity The Carbon Community; researchers from Imperial College London; Royal Botanic Gardens, Kew and the University of Sheffield, along with hundreds of citizen science volunteers.

Located near Llandovery, Wales, the study is the largest of its kind, spanning around 12 hectares with 72 individually managed trial plots. It looks at two forest types (mixed broadleaf woodland and monoculture Sitka spruce) and two nature-based interventions (microbial enrichment and enhanced rock weathering) applied on their own and in combination.

The study comprises over 25,000 trees, of which 6,400 are individually bar-coded and measured every year during the annual Big Tree Measure. The scale of the work is possible thanks to the hundreds of citizen scientists who have taken 75,000 measurements during the first four years, providing a robust dataset that allows researchers to calculate differences in above-ground biomass and associated carbon storage.



Measuring trees. Credit: Paul Box



For microbial enrichment, 200ml of soil inoculum was added to the tree roots at the time of planting.

A slow-release vitamin for trees

When rainwater falls on a mountain, rocks slowly weather and break down as part of a natural geological process. Weathering becomes enhanced when smaller particles of crushed rock are applied, increasing the surface areas and accelerating the process. Basalt, the rock used in the study, is a common silicate rock in the earth's crust. Typically quarried for larger particles used in roads and construction, the quarrying process produces large quantities of smaller particulate – called basalt dust – as a by-product.

Basalt dust was applied twice during this research: ahead of ground preparation in 2020 and again between the trees in 2023. The impact on tree biomass has been significant: native woodland plots amended with basalt stored up to 27% more above-ground carbon after four years compared with untreated controls.

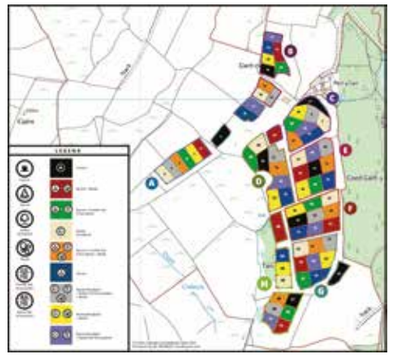
To understand the mechanisms behind this striking tree growth, researchers monitored soil pH and inorganic nitrogen pools, analysed elemental composition in leaf samples and quantified the minerals released from rock weathering.

As the basalt minerals weathered, they improved tree nutrition. Like a slow-release vitamin, they released nutrients such as calcium and magnesium directly into the soil. Weathering also increased soil pH from 5.3 to 5.65 in the first year, which made existing nutrients, nitrogen and phosphorus, more available to the trees.

Crushed basalt application is likely to be most useful on nutrient poor or acidic sites. Soil temperature, pH, moisture and proximity to basalt quarries all matter, making many western and northern parts of the UK particularly suitable for deployment.

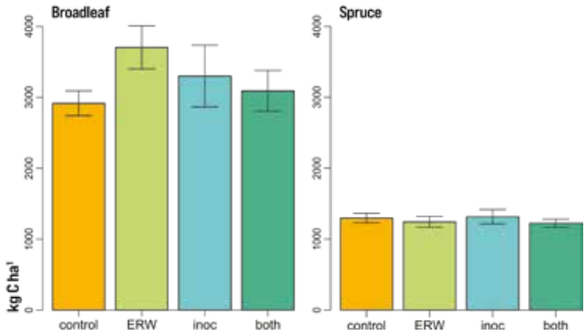


"Time slows down, absorbed in a task, but pausing to look closely at a tree or at the views now and then is good for the soul. It is a reminder of why we need to work ever harder to protect our endangered natural environment." Citizen science volunteer, 2025 Credit: Paul Box



The study involves eight treatment combinations plus an unplanted grassland control treatment, each of which is replicated eight times across the site in a block design.

Response by forest type after four years



For **broadleaf woodland**, the increase in kg of carbon per hectare is +787 kg C ha^{-1} for enhanced rock weathering and +335 kg C ha^{-1} for microbiome inoculation. When the two treatments were combined, they did not accelerate tree growth in the first four years.

This was surprising, as researchers had predicted that more active mycorrhizal biomass would accelerate rock weathering. One hypothesis is that the crushed basalt provided nutrients directly to the trees, which suppressed their investment in mycorrhizae (fungi). Results showed that combining the interventions resulted in a distinct fungal community, and further research is required to understand the interaction and impact.

In the conifer woodland, there was no increase in above-ground carbon after four years. One hypothesis is that Sitka is already well suited to acidic soils and thus did not see a benefit from the crushed basalt. Note that the impact of the microbial inoculum was strongest in the first year and had declined to zero after four years.

Both enhanced rock weathering and microbial enrichment are promising tools that foresters can help refine, test and adapt across different sites, species and objectives.

Microbial enrichment to jump-start establishment

Trees form close associations with mycorrhizal fungi and bacteria that help them to access water and nutrients. In new areas of woodland creation, these partners may be scarce or absent in the soil. This study was established on what was previously an upland sheep farm, and to give the microbiome a jump-start, a scoop of soil from a nearby woodland was added to the tree roots at the time of planting.

After four years, microbial enrichment tended to increase above-ground biomass in native broadleaf woodland plots by 13%. Responses varied strongly by species, with oak and Sitka having the strongest benefit – likely because the broadleaf inoculum was sourced from a predominantly oak forest and the conifer inoculum from a Sitka plantation.

The strongest effects from microbial enrichment occurred in the first year after planting, with tree growth around 45% higher than in control plots. The largest trees were 86% less likely to die than the smaller trees, suggesting that – for native woodland restoration and commercial forestry on degraded soils or challenging sites – microbial enrichment could offer a practical way to improve establishment success. It is a promising tool with clear potential to optimise inoculum choice in future research.

What's next for Glandwr Forest?

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Both enhanced rock weathering and microbial enrichment are promising tools that foresters can help refine, test and adapt across different sites, species and objectives. Support is needed to extend these studies to additional locations to provide further evidence for policy and practice. The Carbon Community is actively looking for additional sites to replicate these exciting results and asks owners of afforestation projects to get in touch if they are interested in running a small replica field trial.

Since 2020, the community involved at Glandwr Forest has grown alongside the trees – a unique blend of researchers, citizen science volunteers and an environmental charity looking at how practical tools can increase the amount of carbon captured by every tree planted in Wales and beyond. Thank you to everyone who has contributed to this work so far, and thank you for being a part of this very special community.



Crushed basalt was applied in 2020 prior to ground preparation at 40 tonnes per hectare. The lime spreader was fitted with a skirt to ensure the basalt was applied to the appropriate research areas.

Waring, B.G., Averill, C., Bidartondo, M. *et al.* Microbiome manipulation and enhanced weathering influence tree growth in reforestation. *Commun. Sustain.* **1**, 102 (2026). The full paper is available at **nature.com/articles/s44458-026-00103-0**

Find out more about the study at **carboncommunity.org/glandwr-forest-carbon-study**

Watch the webinar of Dr Waring discussing the results together with the Carbon Community's Scientific Advisory Board at **youtu.be/KYJdXB2uByY**

To enquire about hosting a replica field trial, **email info@carboncommunity.org**

EVENT

EVENT

NATIONAL TREE OFFICERS CONFERENCE 2026

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The National Tree Officers Conference (NTOC) returns on 4 November 2026, bringing together tree professionals from across the UK for a day of insight, discussion and professional development. This year, the conference heads to Sheffield for the first time, providing a fitting backdrop for one of the most important events in the arboricultural calendar.

Hosted jointly by the Association of Tree Officers, Institute of Chartered Foresters, London Tree Officers Association and Municipal Tree Officers' Association, NTOC continues to provide a unique forum for local authority tree professionals and the wider sector to connect, share experiences and explore the challenges shaping the future of trees and green infrastructure.

As pressures on our urban trees continue to grow, the need for evidence-based practice, strong professional networks and shared learning has never been greater. From climate change and biodiversity loss to development pressures, biosecurity threats and increasing public expectations of green spaces, the issues facing tree officers are becoming more complex and interconnected. NTOC 2026 has been designed to address these issues, offering practical insights and inspiring ideas from professionals working across the sector.





This year's programme features an impressive line-up of speakers covering topics that are both timely and highly relevant. Delegates will hear how Oxfordshire County Council has used the Capital Asset Value for Amenity Trees (CAVAT) system to strengthen tree protection and accountability for utility works, while other sessions will explore evolving approaches to tree risk management, urban forest canopy cover analysis, storm resilience and woodland protection.

Several presentations will focus on the opportunities presented by data-driven decision making and strategic planning. Professor Cecil Konijnendijk FICFor (Hon) will examine the strengths and limitations of urban tree metrics, while Scott Watson will share lessons from Hartlepool's pioneering Tree Equity project. Other sessions will address critical issues such as illegal felling, tree health preparedness, oak processionary moth management and the prosecution of damage to ancient woodland.

Beyond the presentations, NTOC offers one of the best networking opportunities available to tree officers, arboriculturists, planners and urban forestry professionals. The conference brings together a diverse community of practitioners who share a commitment to ensuring that trees continue to deliver environmental, social and economic benefits for future generations. Attendees can expect valuable discussions, opportunities to exchange ideas with peers and plenty of inspiration to take back into their own organisations and projects.

NTOC 2026 promises a rewarding day of learning and professional connection. With tickets priced at £55, early booking is recommended to secure your place at this highly anticipated event.

To find out more about the programme and book your ticket, visit **charteredforesters.org/event/national-tree-officers-conference-2026**. We look forward to seeing you in Sheffield this November!