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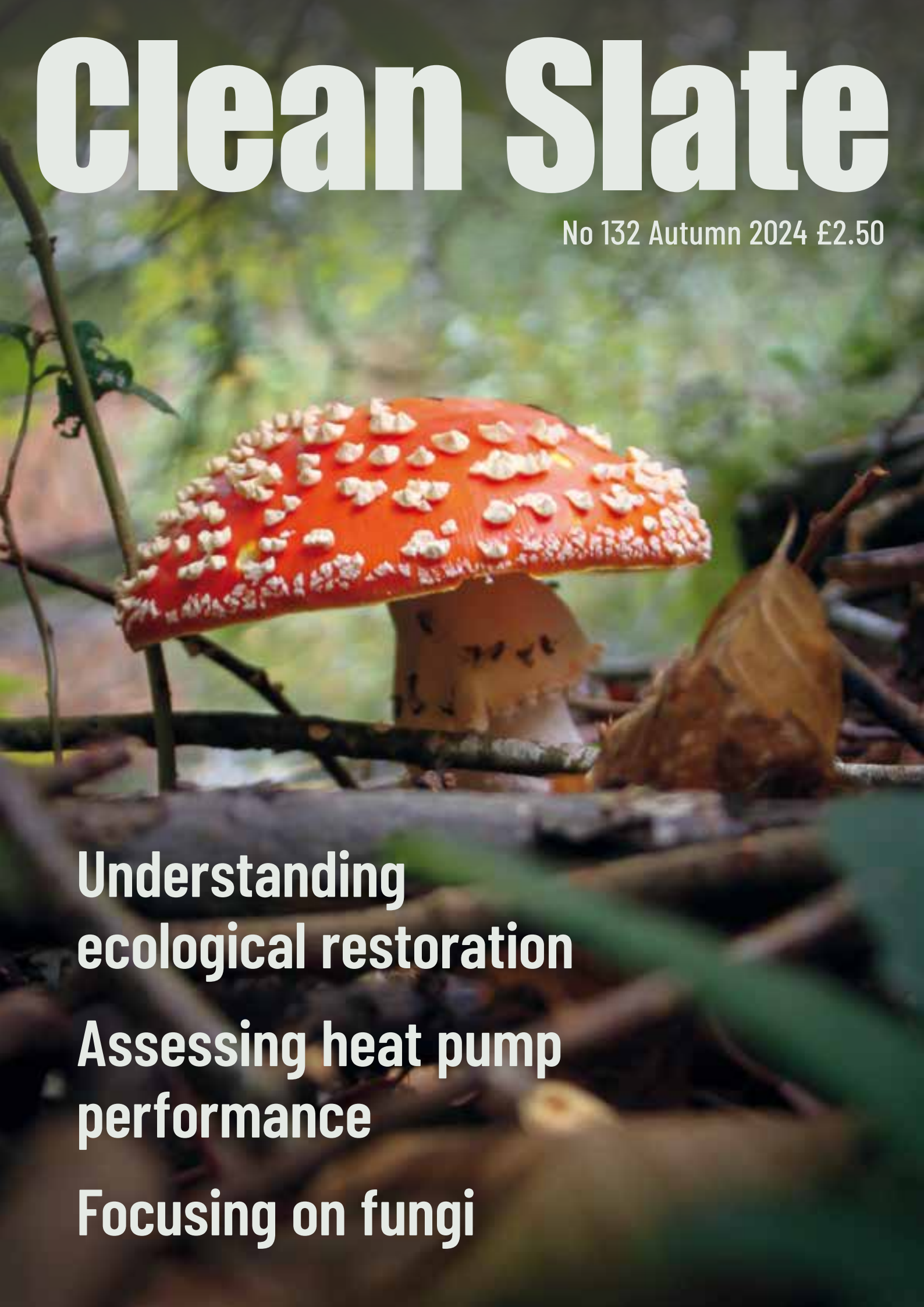

Understanding ecological restoration

Assessing heat pump performance

Focusing on fungi

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EDITORIAL

Eileen Kinsman

An ecosystem of changemakers

For any ecosystem to be successful, diverse species must collaborate, share resources and evolve for mutual benefit. Each part of the complex web has its role to play in ensuring the success of the whole.

This strikes me as a fitting metaphor for CAT's extended family of students, graduates, lecturers, members and supporters. In the face of the climate and nature crisis, we must all do what we can to nurture, protect and enhance the systems that sustain us.

The diversity of stories in these pages is testament to our wide-reaching impact. From ground-breaking research into the soil we depend on to feed us, to the development of perennial green manures, to work ensuring the take-up of renewable heat technologies, the CAT community is taking practical action right now.

By linking up, partnering together and supporting each other, we are ensuring our ecosystem of changemakers is not just surviving but thriving.

Whatever action you're taking towards a safer, healthier and fairer future, thank you. By continuing to support CAT you are part of a movement that is far bigger and more impactful than the sum of its parts.

Eileen Kinsman, co-Chief Executive Officer

News from CAT's Graduate School

In July students joined us for inspiring lectures, hands-on practical workshops and eye-opening field trips on subjects including food production and sustainable building materials.

Students taking our Science of Sustainable Food Production module explored the benefits and impacts of a range of food production methods, including practical sessions and a visit to the Institute of Biological, Environmental and Rural Sciences (IBERS) at Aberystwyth University to hear more about its research work in plant science.

Those choosing our Sustainable Building Materials module got hands-on experience with a range of materials, including earth, timber, straw and hemp-lime plaster. Through workshops, lectures and discussions, and seeing the materials in use in our rammed earth theatre, they explored different ways of using low-impact materials.

On 16 May we invited businesses and organisations to CAT for a careers fair. Students learned about some of the many work opportunities and green careers available to them following their studies at CAT. Thank you to Dulas Ltd, Loco Home Retrofit, Marches Energy Agency, Heritage Trust Network and Project Groundwater for being involved.

There's still time to apply for a place on a postgraduate course with us this September. Find out more at www.cat.org.uk/gse or by emailing study@cat.org.uk or calling 01654 705953.

New volunteering opportunities

CAT has a new Volunteering Manager, Holly Owen, thanks to funding from the Wales Council for Voluntary Action (WCVA). This means more local volunteering opportunities, partnerships and qualifications, as well as more of a focus on wellbeing and diversity.

Holly says, "I've really enjoyed working with the volunteers, they bring so much lived experience locally and from around the UK, and I'm incorporating their suggestions for future volunteering opportunities. Volunteering with CAT's Woodlands and Natural Resources department or Gardens department is ideal for people starting their conservation careers as well as those planning a career change. We're also looking for support with copywriting, design and proofreading in communications, and with fundraising and education. It would be great to have more Welsh first language volunteers."

Are you looking for a new volunteering opportunity? Contact volunteering@cat.org.uk for a chat.

WCVA CGGC

Arlennir gan Lywodraeth Cymru Funded by Welsh Government

Gwirfoddoli Cymru Volunteering Wales

CAT's Tim Coleridge talks urban climate action

Tim Coleridge, Programme Leader at CAT's Graduate School of the Environment, was invited by Islington Council's citizens' panel on climate adaptation and resilience to give a talk and workshop. The panel is giving local people the opportunity to help shape the council's approach to creating a greener, healthier borough. A focus of the talk and workshops on Saturday 1 June was on designing streetscapes for flood resilience, increasing green infrastructure and street shading, and adapting existing building facades for heat stress. Dr Laura McGovern, Public Health Registrar at Islington Council, said, "It was excellent. Tim's talk and workshops provided a really strong foundation for future citizens' panel sessions."

Dulas wins business award

In May, Dulas Ltd, the leading renewables business founded at CAT, won SME Exporter of the Year at the Wales Business Awards. Sponsored by the Welsh Government, the award showcases and celebrates small and medium-sized enterprises that have achieved significant export growth.

Catherine McLennan, Commercial Lead at Dulas, said, "This is a fantastic achievement for our team, and we are so grateful for this recognition. We have pioneered the effective use of renewable energy for over 40 years, and we are thankful for the support of the Welsh Government over the years on our exporting journey."

In April Dulas was also highly commended by the Department of Business and Trade in its Made in the UK, Sold to the World campaign. The awards were created to celebrate the global trading success of small businesses across the UK and showcase the impact of UK-made products on a global scale.

Congratulations Dulas!

AUGUST 2024

15	Basic Tool Skills
17	Compost Toilets
18	Reedbeds and Waste Management
24	All About Bees – A Family Day Out
25	Beekeeping Taster Day

SEPTEMBER 2024

7 - 8	Fixing Your Damp House
9	Wild Wellbeing - Rustic Bench Making
10, 17	Zero Carbon Communities: Carbon Literacy for Communities

SEPTEMBER 2024 (CONTINUED)

13 - 16	Timber Framing for Everyone
14	Introduction to Renewables for Households
15	Wild Wellbeing – A Day Out in Nature
20	Gardening for Nature
30 – 3 Oct	Eco Refurbishment

OCTOBER

4 – 7	Build a Tiny House
5 – 6	Build a Small Wind Turbine
8 – 15	Zero Carbon Britain: Carbon Literacy for Councils
8	Wild Wellbeing – A Day Out in Nature
8	Seed Saving
14	Gardening for Nature
25 – 28	Build a Tiny House

Find out more and book your place online at **cat.org.uk/short-courses** or call us on **01654 705950**.
More courses are being added all the time – please see our website for up-to-date listings.

cat.org.uk/short courses • 01654 705950 • courses@cat.org.uk

Exploring sustainability in the media industry

The final session of a new Media Cymru training programme on making the media industry more sustainable was held at CAT in May/June. Using a Three Horizons approach, the trainees thought about current practices in the media and film-making, the processes involved, and the narratives that keep them stuck in unsustainable practices. They then spent time thinking about how they wanted their industry to be run in 2030, with sustainable practices as the norm.

There was passionate discussion, and sometimes tears, as they worked through what needed to change. The workshops ended with the students identifying actions they could take into their new roles and how they could stay connected to make a bigger difference.

The programme was developed in association with the University of South Wales and training providers Severn Screen and Earth to Action. The cohort of six received a bursary to attend training at studio locations across Wales, culminating in the final training workshop and a celebration at CAT.

Community Energy Wales meeting at CAT

In June, CAT hosted the annual meeting of Community Energy Wales, a not-for-profit membership organisation that provides assistance and a voice to groups working on community energy projects across Wales. The benefits of community energy projects can be felt throughout communities. But – as an increasing number of community organisations are discovering – the journey from an initial idea to the realisation of a project can be challenging. An aim of the conference was to help create the conditions in Wales to allow community energy projects to flourish and communities to prosper. Delegates were inspired by a wide range of real-life successful case studies to help them on their own community energy journeys.

A net zero Wales by 2035?

The Wales Net Zero 2035 Challenge group, led by ex-Environment Minister Jane Davidson, who introduced the Welsh Government's Wellbeing of Future Generations Act, met at CAT in May. Over two days, the group, including CAT's Paul Allen, explored potential pathways to net zero by 2035, ahead of the current target date of 2050. Their discussions included the impact on society and sectors of the economy and how any adverse effects may be mitigated, including how the costs and benefits can be shared fairly. The results of the research will be made public in the autumn.

Great Big Green Week

Between 8 and 16 June, people across the country came together for the Great Big Green Week. This year was all about swaps we can make to help create a safer, greener, fairer future. CAT hosted the Mid Wales stop of a nationwide tour organised by Climate Cymru. Paul Allen gave visitors a tour of the CAT site and an introduction to the skills people can gain (and swap) at CAT. We were excited to be featured in the Great Big Green Week wrap-up film on social media, reaching new climate and nature changemakers.

Summer open day

We will be hosting a free summer open day for all the family on Saturday 31 August, offering you the chance to explore CAT's displays, take part in free workshops and hear about our big plans for the future.

Throughout the day, there will be hands-on activities, workshops, tours and talks exploring the themes of green building, renewable energy, ecology, growing and more. You'll have the opportunity to have your say on our development plans with a first look at the designs and the opportunity to take part in accompanying creative workshops.

Free parking is available, and you'll be able to purchase refreshments and lunch at our vegetarian café.

For more information, visit www.cat.org.uk/summer-open-day.

CAT students join in National Gallery celebration

CAT Graduate School students are taking part in an art project led by artist Jeremy Deller to celebrate the National Gallery's bicentenary. The Triumph of Art marks how festivals are part and parcel of art, culture and civic life, and that art and artists can be catalysts of collaboration and joy. The work explores the role art plays in public collections, cultural spaces and museums and looks at the main motivations for mass gatherings: celebrations, demonstrations, commemorations.

The project, which is a collaboration with The Box in Plymouth, Duncan of Jordanstone College of Art & Design in Dundee, Mostyn in Llandudno and The Playhouse in Derry/Londonderry, will culminate in a procession through Wales and the streets of London and a major performance in Trafalgar Square in July 2025.

CAT students will design and create portable structures to be included in the public procession. Designs could be a tent, stage, float or hut – anything that creates a delineated or framed space for performance. They will take a sustainable approach, using methods and materials championed by CAT. The structures designed and built by CAT students will be seen for the first time at this unique celebration.

Join CAT's Board of Trustees

Applications are now open to join CAT's Board of Trustees. This is an exciting time to join CAT, when addressing the climate and nature emergency has never been more important. We have ambitious plans to transform our site in Mid Wales and are developing our next five-year strategy to make an even bigger impact.

We welcome candidates with experience in the private, public or charity sectors. All Trustees need to have experience of strategic leadership and be prepared to get involved in many different aspects of CAT.

We particularly need people with skills and experience in:

- Communications
- Equality, diversity and inclusion
- Finance and accounting
- Fundraising
- Organisational management
- Safeguarding
- The Welsh political and economic landscape

However, we welcome applications from people with broad experience of leadership in any sector.

If you want to play an active part in the strategic oversight of our work and share a passion for CAT's mission, find out more at www.cat.org.uk/vacancies.

The gift of education

Gifts in wills, from people who care passionately about the environment and a better future, make so much of our work possible. A gift in the will of CAT supporter Jane will be invested in enhancing the acoustics in parts of our WISE building, improving the experience of students and visitors.

Jane first visited CAT with her husband and their daughter in the 1970s, soon after the site opened. She and her family went on to develop a close connection with CAT. Jane's brother explains why we chose to honour her legacy in this way:

"In the early 2000s, I gave sessions on building performance to CAT's MSc students, which made me aware of acoustic issues in some parts of the WISE building. This project was attractive, not only addressing a known problem with the otherwise fantastic learning environment but also offering a valuable learning opportunity for students to put their knowledge and creativity into practice."

This learning opportunity has allowed CAT students to develop a range of designs for acoustics improvement and submit them for evaluation by a staff panel. The students then installed their designs – which used hemp insulation with timber framing to absorb the sound – in one of the rooms in the WISE building. The practical building experience and the ability to see their project through from conception to completion exemplifies CAT's approach to hands-on learning.

We are incredibly grateful to Jane and her family for their support.

Free Carbon Literacy workshops

We have secured funding through the Shared Prosperity Fund to offer fully funded Carbon Literacy Certified courses for businesses, community groups, town and community councils, social enterprises and organisations in Powys.

CAT's Zero Carbon Britain trainers will be welcoming groups to take part in this two-part training programme which will support people to become more aware of sustainability-related issues and to create a low-carbon culture within their projects and workplaces. The courses will also help businesses and other organisations to become a Carbon Literacy Organisation (CLO).

Courses are bookable up until the end of 2024, are offered in person and online, and can be bespoke. The topics covered include:

- The latest climate science, projections and impacts, globally and in communities.
- Climate change, a just transition, and issues of equality and vulnerability in communities.
- An assessment of international, national and regional responses to climate change, including an assessment of COP28 and the COP process.
- An introduction to Zero Carbon Britain's research and possible visions for zero-carbon communities.
- Important conceptual tools that participants will find useful in planning and implementing responses to climate change, including prioritising and optimising climate actions and leveraging behaviour change.
- Talking about climate change and climate anxiety as a growing phenomenon.
- The role of councils and communities in the climate and nature emergency.
- Facilitated activities designed to assist participants to apply this learning and identify next steps.
- Relevant resources and case studies.

For more information visit www.cat.org.uk/free-carbon-literacy-training-in-powys

We are also offering free training for individuals through short courses and evening classes. These will be added to the course calendar on our website soon.

A tribute to Roger McLennan

Following his recent passing, we reflect on and honour the special contribution to the regeneration of the CAT site of our dear friend and Head Gardener Roger McLennan.

Over 45 years Roger McLennan nurtured the CAT site from an abandoned slate quarry to the abundant nature space we know and love today. He brought to life the CAT gardens and 'Roger's Field', creating a rich tapestry of veg plots, flower beds, fruit trees, and spaces for nature to thrive.

Roger brought growing to life for thousands of people, inspiring and informing garden team staff, volunteers, members and visitors. He sowed the seeds of change – many people whose lives he touched went on to a career in sustainable growing, creating a ripple effect impossible to measure.

From 1991, his regular Roger's Garden column in *Clean Slate* inspired many of you to get growing, sharing his expertise and wisdom. Roger said, "Respect your food as you respect yourself. Treat it as you treat yourself."

He inspired us in so many other ways too. He was a joyful, honest, kind, mischievous, fun-loving man and a beautiful soul at one with nature. Roger was very dearly loved and is much missed by all who had the privilege of knowing him. CS

"Volunteering with Roger, as the last group before his retirement, was such a privilege. I will be forever thankful to have been a small part of the sanctuary he toiled and cared for over the last 40 years. His memory will live on in the verdancy of the CAT landscape – in the soil, the canopy, and all of us who had the pleasure of sniffing the flowers with him."

Jordan Hau, CAT gardens volunteer in 2023

"Roger was truly a one-off human being and very dear to my heart. Working with him was more an education in living than gardening. He did teach me so much about plants though and what makes them thrive in an unconstrained and harmonious way. Roger's spirit was deeply rooted in the important things in life: peace, love and fun. Maybe that's what made him such a great gardener, teacher and friend."

Petra Weinmann, CAT gardener.

"Even though I didn't work in the gardens, Roger was a regular inspiration to me. If I was delving into a problem for CAT, through a chat over lunch or a walk in the gardens his wisdom would help me reconnect and bring solutions to life."

Paul Allen,
Knowledge and Outreach Coordinator

"Dad truly was an inspiration to us all, he taught us to engage with nature, listen out for birdsong, and that weeds can sometimes be as beautiful as flowers. He also taught us stillness and appreciation of the quiet, as well as a love of music which he would blast out (all manner of crazy and wild tunes) at 6am to wake us up for school. He taught us to embrace life, just as he did."

Cath McLennan, Roger's daughter

"What an absolute legend! For my entire lifetime I've seen my dad dedicate his expertise, knowledge and commitment to his work at CAT, which he never really viewed as work... It was part of his life's mission!"

Laura Pollock, Roger's daughter

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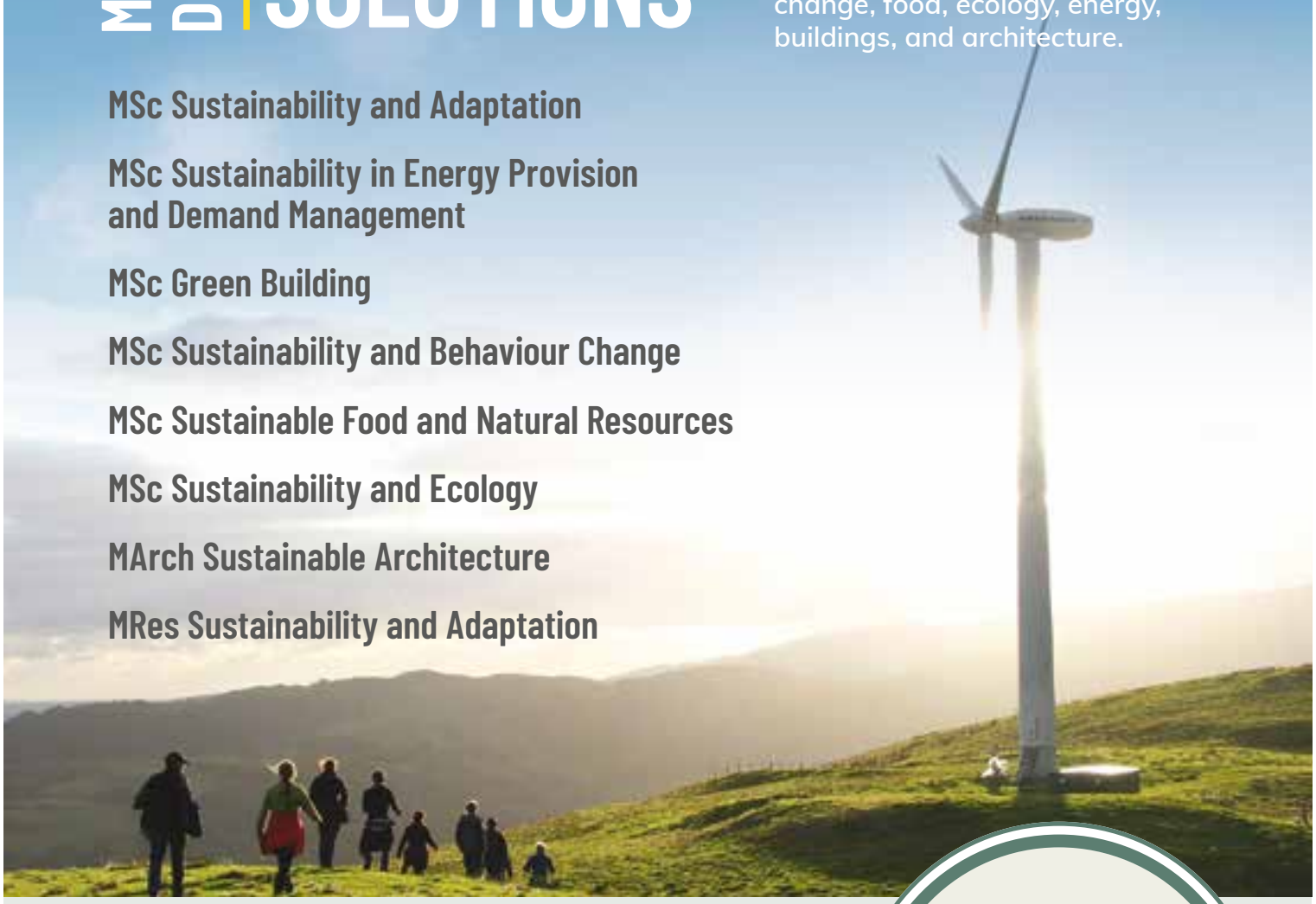
- MSc Sustainable Food and Natural Resources
- MSc Sustainability and Ecology
- MArch Sustainable Architecture
- MRes Sustainability and Adaptation



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CAT members' conference 2024 — The power of community

Last year, the CAT members' conference was preceded by the sad and difficult news of a staff restructure and the temporary closure of the centre to day visitors. Due to a drop in the number of visitors to Wales and the cost-of-living crisis, CAT has experienced a challenging two years. Yet our 2023 members' conference remained as vibrant, inspiring and optimistic as ever. We owe the deepest thanks to all our staff, volunteers, guest speakers and members for bringing their ideas and values to life in celebration of our 50th anniversary, highlighting the power of people coming together during difficult times.

The power of community will be the focus of our 2024 conference. So far, it has been a big year for many reasons – from critical elections to international climate meetings, and continued climate impacts, including the warmest January on record. It could be easy to feel overwhelmed. However, where there is community, there is hope. We do not bury our heads in the sand or give up. We collaborate, share skills, knowledge and tools, and find ways forward.

CAT is not only an environmental charity and a hub for sustainability education. We are also a wide community of like-minded individuals – kind, forward-thinking and pragmatic – who care about the planet and each other. Our members are diverse but united by a shared passion for nature and commitment to creating a safer, healthier and fairer future for generations to come.

This year, we have seen less of our members than we normally would, so we're especially excited to welcome everyone back for this annual gathering. Whether you are a new member, or have been with us for decades, the conference is special for us because we get to hear from you, learn from your work, and thank you in person for everything your support helps to achieve.

This year:

- join us in celebrating some of our most inspiring graduates' stories and research – from the powerful role of fungal communities in forest soils to home energy efficiency and retrofit initiatives
- take part in Carbon Literacy training
- explore Coed Gwern and CAT's sustainable approach to biodiversity and woodland management
- dive into the themes of climate justice and our complex food system
- take the opportunity to speak to energy experts and get hands-on with sustainable building materials.

Friday evening will be dedicated to reconnecting with each other, as well as an optional film screening. On Saturday, we'll host an afternoon dedicated to your own contributions, with an evening Ceilidh (back by popular demand).

As the world grapples with the urgent need for environmental action, the CAT members' conference is a time to re-energise, connect with friends old and new, explore sessions, talks and workshops, and see the impact you are making through your membership. It is your opportunity to develop your personal roadmap towards a zero carbon future. All are welcome. We hope to see you in October.

Key information

Dates: 11th to 13th October 2024

Ticket prices: from £250, plus accommodation (please get in touch by phone or email to enquire about concessions for CAT students, residents local to SY20, and those on lower incomes)

Times: arrivals from 3pm Friday, ending at 12.30pm on Sunday

Accommodation: book a BnB stay in our WISE building, or seek alternative accommodation off site.

Food: seasonal vegetarian meals included with conference ticket

Booking: go to cat.org.uk/annualconference, email membership@cat.org.uk or call 01654 705988

WHY WE TEACH – ecological restoration

Next in our series looking at themes and topics explored by students on CAT Master's degrees, **Dr Jane Fisher** introduces ecological restoration, a key module for students taking our MSc Sustainability and Ecology programme and also a subject relevant to those studying MSc Sustainable Food and Natural Resources and MSc Sustainability and Adaptation.

Introduction

There is great potential for subjectivity in the setting of ecological restoration goals. What kind of ecology do we want to restore? Ecosystems naturally change in their distributions, structures and compositions, according to climate and natural fluctuations. We need ecosystems that mitigate climate change and biodiversity loss while still providing us with essential resources. We therefore must be led by evidence of what has gone before and by our knowledge of what will persist and thrive under future climate scenarios.

Why is the topic important?

All over the globe, natural ecosystems have been reduced in their coverage and biomass and become fragmented. A damaged natural ecosystem cannot sequester carbon, hold water, cycle nutrients or provide habitat for the earth's organisms as effectively as a large intact ecosystem. These ecosystem functions ensure that the globe remains habitable for life. Restoring the world's ecosystems is therefore a key aspect of sustainability. We cannot survive without nature and the functions it provides. How to bring nature and ecosystem functions back is what the science of ecological restoration is about.

What are the key aspects to consider?

Climate change and other human-induced stresses mean the conditions under which ecosystems have evolved have changed rapidly. An ecosystem that was once self-perpetuating may no longer be able to survive in that place, despite restoration efforts. Considering the replanting of UK forests, what species will survive the warmer and drier UK summers, for example? Should we be planting ash trees considering the prevalence of ash die-back? Do we need to consider the multiple uses of land, so ecosystems can provide life-supporting functions as well as the production of food, fuel and timber? Choices and trade-offs must be made.

Ecosystem changes are hard to predict and therefore restoration practices do not always lead to the expected or desired outcome. If the landscape is left to repair naturally will the outcome be predictable? For example, on our Ecological Restoration module, students visit a upland area where ex-conifer forestry land is succeeding, through natural processes, to a mixed woodland, but this young woodland is a mix of fast-growing conifer, blown in from nearby forestry plantations, rhododendron from old estate gardens, as well as buddleia and sycamore, all non-native, and growing side by side with oaks, birches and rowans. In 30 years' time, which species will dominate? Will such novel ecosystems be resilient to climate change and diseases in a way that the older mixes are not? Which outcome will best support insects and birds?

Reintroducing species is an important element of restoring ecosystems.

Studying ecological restoration at Coetir Anian.

The beaver is a prime example in the UK, with its engineering abilities to change the landscape to hold more water, reduce flooding downstream, rewet the ground, and bring about new aquatic ecosystems. However, beavers damage trees and flood land, to the dismay of farmers and forestry workers, and the existing terrestrial vegetation and invertebrates of newly flooded areas will drown. It could be years until the effects of new flooding pass and a new, richer biodiversity emerges.

What are the main teaching methods?

At the Graduate School, we go deeply into natural ecosystem functioning, including influences on food production. Scientifically speaking, ecology is not chiefly about animals or plants. It's about process and function; what does what, what that means, and how we know. We look as objectively as we can at evidence.

We teach ecological restoration though examining fundamental ecological processes before applying them to real-world situations. We consider if we need to choose one use of land over another when visiting the CAT woodlands and wetlands to consider which species or habitat functions we might need to prioritise and how these decisions interact with the general use of the site for education. We visit nearby ex-forestry plantations to examine natural processes at work, and the Coetir Anian (Cambrian Wildwood) project – a large upland restoration project looking to restore peat and upland vegetation using mixed management methods. These trips are a great way to look at ecological restoration in practice and meet the people dealing with the complexities.

But it isn't all UK-based examples. Comparable issues around decision making are made in other parts of the world and Dr Hasseb Irfanullah (visiting research fellow at the University of Liberal Arts Bangladesh and ex-Programme Coordinator of the International Union for Conservation of Nature) presents students with case studies of tropical mangrove restoration and the restoration of land in Bangladesh around refugee camps to examine the impact of these decisions on human quality of life and livelihoods.

We use this mix of lectures, including from other guest speakers such as David Bavin (conservation scientist and post-doctoral researcher at the National Trust) and Christopher Price (ex-Chief Executive of the Rare Breeds Survival Trust and Director of Policy at the Country Landowners Association), to inform group discussion, visit sites and run problem-based learning exercises.

How do students use this learning?

We have several students looking to undertake dissertation projects in restoration. Stuart, who studied the ecological impact of beavers, has presented his findings to the Wildlife Trust, and we have had graduates go on to work in ecosystem or habitat restoration or related fields with the Wildlife Trust, National Trust and Natural England, as well as others who have gone on to study PhDs in allied subjects. Rachel used her Master's thesis, which examined the role of mycorrhizal fungi in meadow restoration, to gain a position as a PhD researcher at Birmingham University.

Study with us

Find out more about CAT Master's degrees, join an on-site or virtual open day, and explore what funding might be available to you – visit our Graduate School web pages or contact Alis at study@cat.org.uk or on +44 (0)1654 705953.

About the author

Jane is Programme Leader for MSc Sustainability and Ecology and MSc Sustainability and Behaviour Change and co-developed the MSc Sustainable Food and Natural Resources programme. She has professional experience in evaluating and restoring freshwater and wetland environments, a PhD in freshwater ecology, and has taught environmental science, biogeography and ecology at universities for over 18 years.

What's holding back heat pumps?

Heat pumps are an extremely powerful way to reduce our use of fossil fuels. But with 35,000 certified installations in 2023, the UK is far short of the 600,000 annual target set in 2020. So, what's the problem? CAT graduate **Colin Meek** shares his research into one potential issue – the gap between forecast and actual heat pump performance.

My energy research firm's work on consumer protection investigations and policy has convinced us that the single most important factor that will determine the success of the energy transition is consumer trust. In law, misleading sales or technical information is illegal. False information can drive consumers to take contractual decisions they would not have taken otherwise, and they cause market failures by putting ethical companies at a disadvantage.

Systemic problems

But those market failures can be caused by other systemic problems that carry the potential to damage consumer trust. In the UK, renewable installations must be certified (e.g. under the Microgeneration Certification Scheme – MCS) to be eligible for financial incentives (such as the Boiler Upgrade Scheme). Certified installers must give consumers a formal performance estimate using the approved methodology. The theory is that these documents are less likely to be misleading and should give consumers reassurance. Research we carried out in 2022 found that the vast majority of consumers value the provision of a fair estimate of energy generation above all other consumer protections.

In reality, performance estimate documents are not always calculated correctly and may not be provided at all. But we've also identified issues with the methodologies that underpin the industry's heat technology performance forecasts, because the algorithms aren't providing realistic results.

With support from a range of consumer protection organisation and agencies, we have completed a series of research projects to identify and describe these systemic problems and develop solutions.

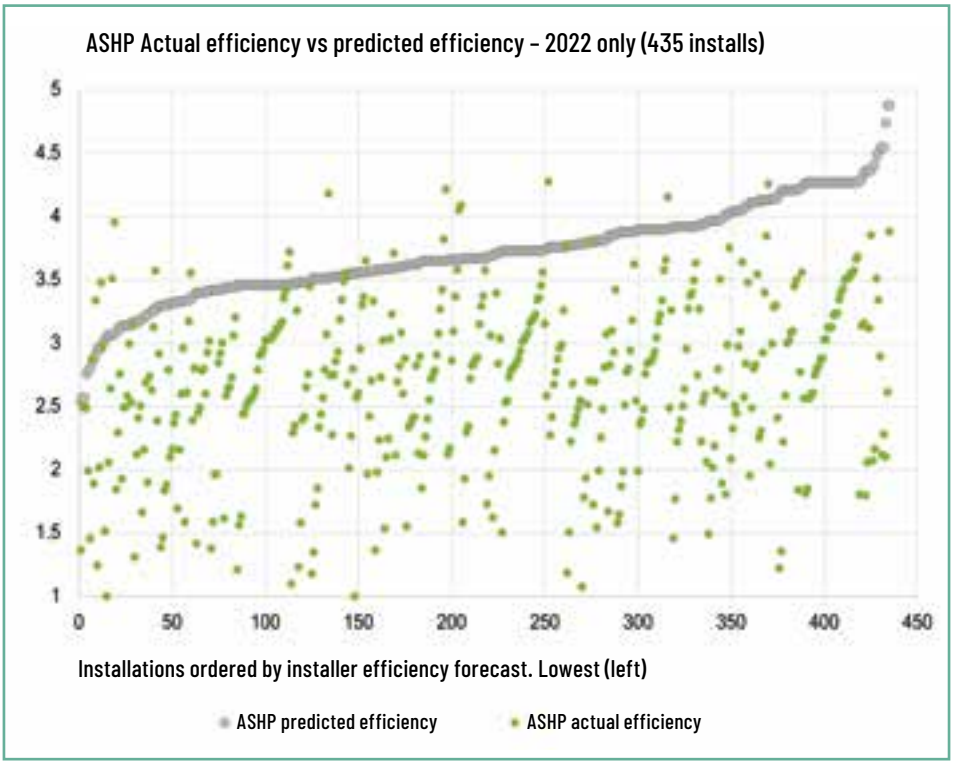

Figure 1 Installations ordered by design SCOP (grey, starting far left) and the corresponding actual efficiency (SPF) shown (green). Showing 435 ASHP 'metered for payment' installations from 2022. See Table 1.

Heat pump efficiency and the SCOP metric

The SCOP (Seasonal Coefficient of Performance) is a measure of heat pump efficiency. In 2017, consumer performance estimates based on SCOP became compulsory (for certified installations). A SCOP forecast of, for example, 3.5 means that the installation will generate 3.5kWh of heat energy for every 1 kWh of electricity consumed by the heat pump.

There are two critical problems in the way the SCOP is being used. Firstly, the SCOP figure obtained from the MCS database of heat pumps is an estimate of product performance but is being used to predict system efficiency. SCOP does not factor in all the electricity used in the installed system and the system efficiency will almost certainly be worse. Secondly, research shows that efficiencies measured in-situ tend to be much lower than SCOP forecasts. The measured efficiency of an installed heat pump is known as the Seasonal Performance Factor (SPF) and SCOP has proven to be a terrible proxy for the SPF.

Research I carried out in 2017 convinced me that SCOP forecasts could never give consumers a realistic guide to likely installation outcomes. Field trial results released that year for nearly 300 air source heat pump (ASHP) installs found that in-situ efficiencies were about 2.5 (allowing for most system losses) but industry bodies disputed the results.

In 2018, I became aware that a subset of installations, under the Domestic Renewable Heat Incentive, were being monitored as a condition of eligibility. I obtained that data in 2019 using a Freedom of Information request and the subsequent data analysis formed the basis of my CAT Master's dissertation. Importantly, the dataset not only included

	Actual efficiency Mean – SPF	Forecast efficiency Mean – SCOP
ASHP (510 installs)	**2.71** [2.61, 2.68]	**3.25** [3.59, 3.63]
GSHP (88 installs)	**3.07** [3.16, 3.32]	**3.65** [3.90, 4.00]

Table 1 – Heat pump actual efficiency vs forecast efficiency.

	Actual efficiency Median – SPF [IQR]	Actual efficiency Mean – SPF [95% CI]	Forecast efficiency Median – SCOP [IQR]	Forecast efficiency Mean – SCOP [95% CI]
System boundary	Ofgem specified	Ofgem specified		
ASHP (1,431 installs)	**2.69** [2.26, 3.07]	**2.65** [2.61, 2.68]	**3.59** [3.41, 3.86]	**3.61** [3.59, 3.63]
GSHP (286 installs)	**3.26** [2.83, 3.64]	**3.24** [3.16, 3.32]	**3.93** [3.59, 4.29]	**3.95** [3.90, 4.00]
ASHP (2022 only – 435 installs)	**2.74** [2.26, 3.11]	**2.67** [2.61, 2.73]	**3.67** [3.46, 3.92]	**3.71** [3.68, 3.74]
GSHP (2022 only – 116 installs)	**3.34** [2.88, 3.79]	**3.31** [3.18, 3.43]	**3.99** [3.73, 4.43]	**4.06** [3.97, 4.14]

Table 2 – Actual efficiency vs forecast efficiency – main results and results for 2022 (the most recent cohort of installations included).

the figures necessary to calculate installation efficiency, but also the installers' forecast performance. The calculated results published at the International Sustainable Ecological Engineering Design for Society (SEEDS) Conference in 2022 are shown in Table 1.

In a further project, part-funded by DESNZ, the Ground Source Heat Pump Association and the Renewable Energy Consumer Code, I carried out another analysis this year using a much larger sample. The main results are provided in Table 2.

Note: The system 'boundary' refers to the system components included in the measurement of electricity consumption. The 'Ofgem specified' boundary includes most of the electricity consumption and is closest to the results for the H4 boundary in Table 3.

Because the results in Table 2 are restricted to a sub-set of installations, we don't know if the results are representative, but the sample size is very large and there is good correlation with the recent Electrification of Heat (EoH) field trial, also funded by DESNZ and carried out by Energy Systems Catapult. Those EoH results are set out in Table 3.

What does this mean for consumers?

So, are UK consumers being given estimates that likely exaggerate heat pump performance significantly? The short answer is yes. Table 2 shows that the mean ASHP efficiency for installations carried out in 2022 was 2.67, yet the mean SCOP forecast was 3.71 – a difference of 1.04. Critically, both of my studies and the EoH field trial found almost no correlation between the design SCOPs and the in-situ efficiencies. These results show that SCOPs used to predict system performance are therefore effectively meaningless (as illustrated in Figure 1).

The authors of the EoH study have concluded that SCOPs 'appear to consistently overestimate performance' and called for revisions so consumers are given a 'realistic picture' of performance.

Some heat pumps do perform really well. In my latest study (Table 2), exactly one third of ground source heat pumps (GSHPs) and 8% of ASHPs were performing at SPF 3.5 or above, and 67% of all GSHPs and nearly 30% of all ASHPs performed at SPF 3.0 or above. Overall, however, the best information we have is that the median ASHP efficiency using the H4 boundary is between 2.7 and 2.8, and this is in obvious contrast with what consumers are being told.

Important lessons

The installation of a heat pump in a home with an average heat demand will typically prevent nearly three metric tonnes of CO_2 emissions per year. Building consumer trust in this technology is vital to meet installation targets towards a zero carbon Britain. We are working hard to improve the performance forecasting methodology, but the industry process is painfully slow. Our research highlights important lessons for all stakeholders:

There is a need for expert scrutiny independent of industry. Consumers value neutral and reliable performance information above all other protections.

Far more emphasis should be placed on in-situ 'real world' performance via system monitoring.

All stakeholders should define the information consumers need to make informed decisions in a process of genuine collaboration.

Consumers need to be proactive to identify the best installers to maximise their chance of a high-quality installation. For example, by obtaining references and viewing past installs and not being driven by price alone.

About the author

Colin is a CAT graduate and Managing Partner of rb&m, a consultancy dedicated to consumer protection in the energy transition. The partners sit on a range of industry working groups, including the technical working groups for heat pumps, biomass and small wind generation.

	Median efficiency – SPF [IQR]	Mean efficiency – SPF [95% CI]	Median efficiency – SPF [IQR]	Mean efficiency – SPF [95% CI]
System boundary	H2	H2	H4	H4
ASHP (428 Installs)	**2.93** [2.67, 3.19]	**2.95** [2.90, 2.99]	**2.78** [2.55, 3.05]	**2.81** [2.76, 2.85]

Table 3 – EoH study results reported in April 2024. The EoH study did include ground source source heat pumps but the sample size was small.

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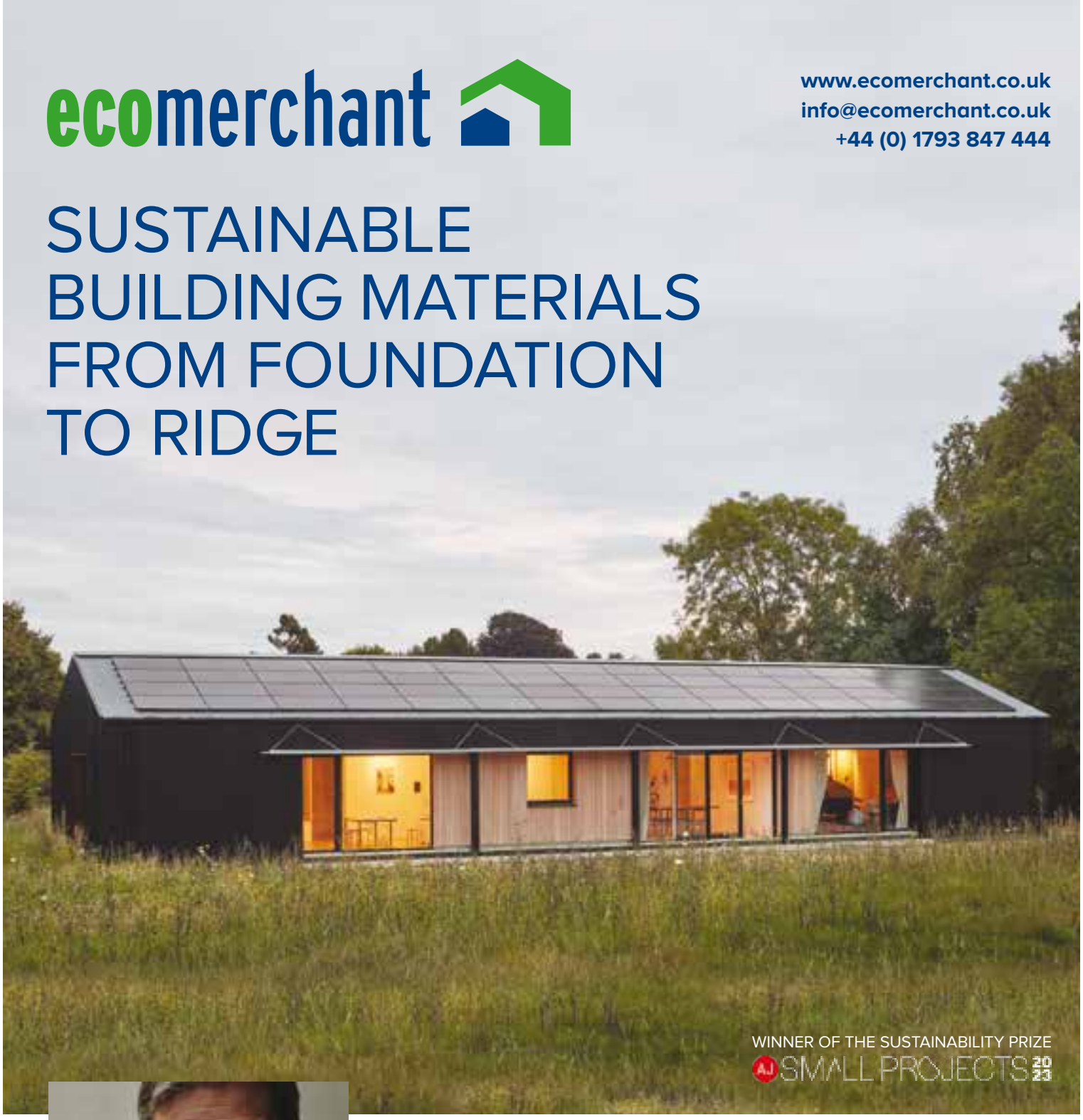

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CAT Conversations: Rachel Calder, CAT graduate

Rachel Calder studied Sustainable Food and Natural Resources at CAT from 2021 to 2023, exploring the role of mycorrhizal fungi in meadow restoration for her dissertation. We caught up with her to ask where her experience at CAT has led her and what impact her studies have had on her career.

Hi Rachel. What are you working on right now?
I'm doing a PhD looking at the impacts of elevated CO_2 levels on mycorrhizal fungi and potential implications of this for woodland nutrient cycling. My research uses the Birmingham Institute of Forest Research (BIFoR) Free Air Carbon Dioxide Enrichment (FACE) experiment, which exposes sections of a mature oak woodland to increased CO_2 levels throughout the growing season. A lot of uncertainty remains around the extent to which soil nutrient levels may limit tree growth as atmospheric CO_2 increases. Given the importance of forests as carbon sinks, a better understanding of these processes is vital. Mycorrhizal fungi could play a crucial role here as they can help plants access scarce soil nutrients.

Just like we humans have 'friendly bacteria' in our gut, plants too depend on microbial helpers. The vast majority of land plant species form partnerships with mycorrhizal fungi. These fungi colonise plant roots and receive all the carbon they need directly from their plant host. In exchange for this carbon they can help the plant acquire water and nutrients from the soil and resist stresses like pests, pathogens and heavy metal toxicity. In addition to the benefits they provide directly to their plant hosts, mycorrhizal fungi play crucial roles in broader ecosystem functioning – for instance, they exert considerable influence over soil carbon sequestration.

What was the path that brought you here?
I've ended up where I am now as a direct result of my CAT dissertation, exploring the potential significance of mycorrhizal fungi in grassland restoration. I enjoyed the dissertation research enormously and was keen to continue exploring similar questions. My very supportive supervisor encouraged me to apply for PhD opportunities that would enable me to take forward what I learned during my dissertation.

What are the best things about what you're doing now?
Being part of something bigger. Previously I had hesitated about going into academic research because I worried about becoming too specialised and perhaps losing sight of the bigger picture. But a huge number of people are involved with BIFoR FACE, each looking at different aspects of the ecosystem response (everything from the leaves of the canopy down to the soil microbiota). My own research feeds into this wider, collaborative effort to answer big and important questions around forest responses to global change and what the wider repercussions might be.

What was your background before CAT?
I took the (ahem) perfectly standard career pathway of a history degree at Cambridge University followed by an eight-year break from academia, much of which was spent working in Lake District youth hostels, before returning to study at CAT. I didn't have a great time at Cambridge and it really put me off further study. I did have a great time in the Lake District but became increasingly preoccupied with the climate and ecological crisis and eventually wanted to leave and do something more connected with this.

What made you choose to study at CAT?
It all started with a CAT webinar I attended during lockdown. That got me interested in CAT and tempted me back towards formal education as I came to realise that CAT was about as different from Cambridge as it is possible to be. Coming from a non-science background (and regretting my original subject choice but unable to afford a second bachelor's degree) it was also important for me that CAT welcomes people from all disciplines onto its MSc courses. I used to spend a lot of thought on conundrums like, "Which is less bad, oat milk in tetrapaks or cows' milk in reusable glass bottles?" So the Sustainable Food and Natural Resources course seemed ideal.

What impact have your studies at CAT had?
Studying at CAT altered my attitude towards academic research as a potential career. The idea of pursuing research previously seemed like a self-indulgent option for me – something I would enjoy, but which wouldn't do any broader good. At CAT we had a lot of inspiring lectures from people whose research was very much directed towards important real world goals, and I came to appreciate that research doesn't have to be something that just happens within an academic ivory tower.

What skills or know-how gained at CAT are you using in your career or projects?
I really appreciated the flexibility of the CAT courses – the potential to shape them to your own interests and objectives. As a result, I was able to develop a specialism and gain a lot of

subject-specific knowledge that I have taken forward into my PhD. Perhaps more importantly though, coming from a humanities background, CAT gave me the skills I needed to become a scientist. I was taught the basics of statistical analysis, I gained some experience of ecological fieldwork, and I learned how to design – and critique! – my own experiments.

What are your future plans?

I'm currently thinking I'd like to continue doing research, provided it's attempting to address relevant and important questions. The CAT ethos of striving for positive change remains important to me. It's early days with the PhD though – maybe ask me this question again in three years!

CAT Stories

To tackle the climate and nature crisis, people need the skills, knowledge and tools to take action across the world for a better future. Meet CAT graduate Marina Rees who is using her learning to make positive change happen.

Marina graduated with an MSc in Sustainability and Ecology from CAT in 2022. She now works for Natural England, the government's independent advisor for the natural environment in England. As a Marine Lead Advisor, she provides advice on working near or within Marine Protected Areas (MPAs), which includes licensing, conservation and restoration management.

The skills Marina picked up at CAT, such as gathering data to assess habitats, have become an integral part of her work. Currently, her focus is on working on projects within the Solent, providing knowledge and support to ensure projects are mindful of the natural environment. Additionally, as the lead condition assessor of her team, she oversees checking the condition of protected sites and habitats.

Initially studying fine art as an undergraduate, Marina was able to explore and channel her curiosity around our relationship with the natural environment through her practice. Her interest gravitated towards marine biology and ecology, and she started taking up roles within museums such as the Natural History Museum in London and a whale museum in Húsavík in Iceland.

Her decision to study at CAT was spurred on by her initial intention to delve deeper into the scientific aspect of her practice. She later found that CAT's values aligned with her own, which encouraged her to enrol onto the course ahead of other postgraduate courses she was exploring.

Studying at CAT has had two significant impacts on Marina. The first being its contribution to her finding her new job at Natural England, and secondly in giving her the confidence and skills to apply science to her practice, combining her interests to create art that highlights environmental issues, raising awareness using both imagery and supporting empirical data.

Marina says: "Studying at CAT has been an important part of my career. Not only has it helped me gain the scientific skills I needed to develop in my practice, but it has nurtured the cross-pollination of ideas which I believe leads to innovative solutions to the climate change and biodiversity crisis."

If you would like to share your CAT story, email members@cat.org.uk to tell us how CAT has influenced your work, volunteering or daily life, and what the community means to you.

Planting fertiliser forests for sustainable crop production

New research is revealing the potential of perennial green manures in improving soil health without contributing to climate change. **Clo Ward** shares the latest findings on this greener way to grow.

Petra and volunteers applying dried alder as a PGM.

In issue 125 of *Clean Slate*, we presented 'The Nitrogen Problem', explaining how various sustainable methods of supplying nitrogen to crops come with advantages and disadvantages for mitigating climate change and increasing biodiversity. At that time, we were just beginning the Perennial Green Manures project, which has been exploring a possible solution.

What are perennial green manures?

Perennial green manures (PGMs) are made from the foliage of perennial plants, which is harvested and added to the soil to fertilise crops. Many different plants can be used as PGMs, including nitrogen-fixing trees such as alders, other fast-growing trees such as willows, and ground-covering clovers, grasses and comfrey.

Unlike the production of manufactured fertiliser, making nitrogen available to crops via nitrogen-fixing PGMs does not cause carbon dioxide emissions. And unlike traditional green manures grown in rotation, PGMs can be grown on marginal land, making efficient use of farm resources. They still add organic matter to the soil and can be easily applied at any time (fresh, dried or pelleted) to match the crop's nutrient needs. This is important for good yields and to reduce the build-up of nitrogen compounds in soil, which can be lost as nitrates into rivers or as the powerful greenhouse gas nitrous oxide.

Insights from the perennial green manures trials

Continuing CAT's long tradition of research and innovation, Petra Weinmann and the Gardens team were one of five sets of growers that took part in PGM trials in 2023. In the CAT allotment, they experimented with fertilising crops with alder and clover leaves that had been collected and dried the previous year. This was compared with a control with no addition, CAT's own compost, and a mix of half compost and half PGMs.

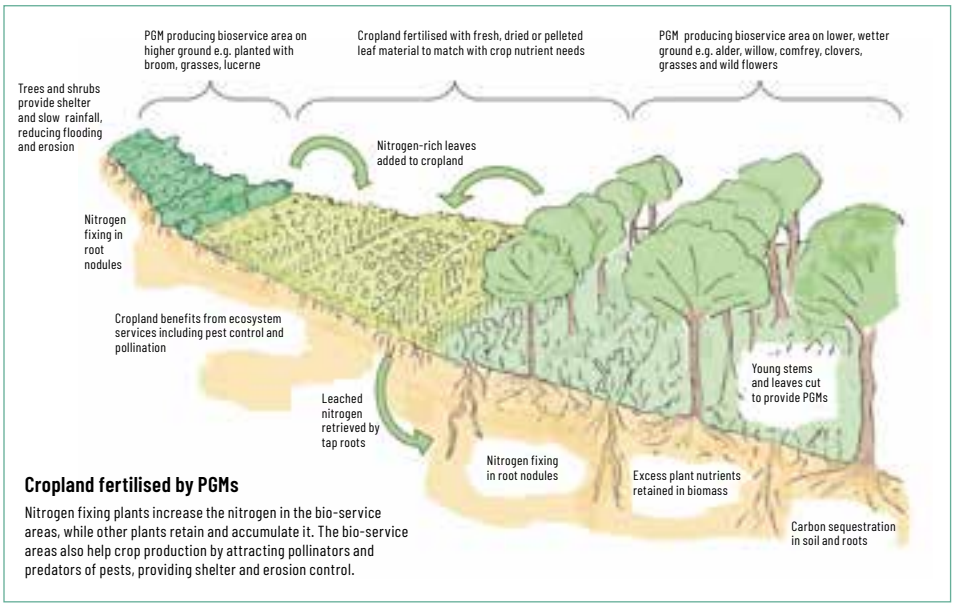
Petra found that PGMs boosted crop yields above those of the control, but yields were usually lower than when using CAT's own wonderful compost. Across the trials, however, we found that growers were often adding large amounts of compost or manure containing more nitrogen than we thought the crops would need. Efficient use of nitrogen is important for sustainability, even with organic materials, and it's possible that use of a wider range of additions that benefit the soil in different ways might help enable this.

New learning

Key to good nitrogen-use efficiency is to add the material so it will decompose at

Fertilising kale with PGMs

Alongside the PGM project trials, Maria Cooper, a student on CAT's Sustainable Food and Natural Resources MSc programme, researched PGMs for her dissertation. Maria experimented with fertilising kale plants with leaves of alder, gorse and broom, and found that alder and broom successfully fertilised the kale with yields as good as those from manufactured fertiliser. The kale developed deep tap roots when fertilised with the PGMs, which didn't appear when they were fed with manufactured fertiliser. You can read more about Maria's project in our Perennial Green Manures report.



PGMs can be grown on farms in bioservice areas to provide homegrown fertiliser as well as other agroecological services.

the right speed to fertilise crops when they need it. It's easy to add PGMs in specific quantities, but to get the timing just right we need to build up more knowledge on how the different species break down in the soil. Various crops and soils also benefit from different quantities of macronutrients, such as phosphorus and potassium. We found that through careful selection of PGMs with appropriate macronutrient content we could change the soil characteristics to suit the crop; this could enable us to produce higher yields from PGMs and use fewer soil additions overall.

At CAT, though the compost plot gave the highest yields, the plot supplied with half compost and half PGMs also yielded well and may have benefitted from the diversity in the additions. Petra is keen to carry on experimenting with PGMs and says, "If it turns out to be equally effective or better than our compost alone (as I suspect it will), I plan to build PGMs into the regular fertiliser regime in our rotation."

At the time of writing, the final stage of the PGM project is underway, with five growers planting their own 'bioservice' areas designed to benefit their farm ecology as well as supplying appropriate PGMs for their crops. Perennial green manures are very much at the experimental stage, but we'd like more people to join the discussion. Could use of PGMs be scaled up to make a real contribution to sustainable agriculture?

Our report containing results from the trials and ideas for the future can be downloaded at www.dyfibiosphere.wales/perennial-green-manures.

The Perennial Green Manures project was part of the Ecodyfi development trust delivering sustainable community regeneration in the Dyfi Valley and funded by the Co-op Foundation's Carbon Innovation Fund.

About the Author

Clo Ward has been an organic gardener for 30 years, including a stint as a CAT display gardener from 2007 to 2012. She has a long-term interest in soil health and perennial systems and is a guest lecturer on our Food and Natural Resources MSc course. Clo is one of many environmental gardeners who started out as a CAT garden volunteer learning horticulture with Roger McLennan, benefitting from his expertise, humour and energy.

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Over the past 50 years, CAT's unique practical and immersive style of teaching has had powerful outcomes, with our graduates and the communities, schools and organisations we've educated and inspired supporting countless individuals to adopt positive solutions in their own lives.

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You do not need to be very wealthy to make this sort of donation. Every gift, big or small, can make a significant impact. Even a modest percentage of an estate (known as a residuary legacy) plays a crucial role in supporting CAT's mission to inspire, inform and enable people to take action for nature and humanity.

After supporting CAT for many years, Audrey and Ken decided to leave a gift in their wills to continue their support into the future. We've been in touch with Brian and Decima, close friends and executors to Audrey's estate, who shared the following:

"My dear friend Audrey passed away recently. She was an enthusiastic supporter of all the work that CAT does in tackling issues surrounding climate change. As executor of her estate, I was not surprised that she had decided to leave a gift in her will for CAT. I think she wanted to help ensure that the vital work CAT undertakes continues long into the future. Leaving a gift in her will was one of the best possible ways to do this."

Gifts in wills are a deeply personal way to support causes close to our hearts and make a lasting impact. It's a way to ensure your values live on and you continue to make a difference long into the future. Thank you for considering this special way of giving.

If you have questions or would like more information, please contact Freya at legacies@cat.org.uk or call 01654 523015.

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1. **Reflect on your values:** Consider how CAT's work aligns with what you want your legacy to be.
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4. **Choose your gift type:** Decide whether you want to leave a specific sum, a percentage of your estate, or particular assets to support CAT's mission.
5. **Communicate with CAT:** This is optional, but we do appreciate hearing from you, so we know your intentions and can keep you informed about the impact your gift will make.
6. **Regular review:** Periodically review and update your will to ensure it continues to reflect your wishes.

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