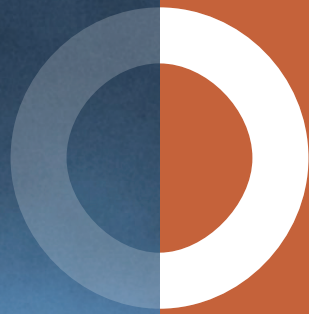


A woman and a young child are walking away from the camera on a gravel path through a forest. The woman is wearing a pink jacket and a backpack, and the child is wearing a blue jacket. Sunlight rays stream through the trees, creating a warm, golden glow. The text 'Truly Useful 21 YEARS' is overlaid on the right side of the image.

Truly Useful 21 YEARS

Tyndall°Centre
for Climate Change Research



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**Truly
Useful**
21 YEARS

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The Tyndall Centre for Climate Change Research was a breathtaking experiment when it launched in November 2000. Twenty-one years later it continues to deliver Truly Useful climate change research.

“While other countries were talking about new approaches for bringing intelligence to bear on the unprecedented challenge of climate change, the UK was actually doing something about it,” wrote Prof Bill Clarke of Harvard University.

The Tyndall way of working rapidly became the international role model for interdisciplinary climate change research that is academically rigorous and relevant for policy and practice. And this continues today. Over its 21-year life so far, the Tyndall Centre has evolved in terms of partners, members and funding mechanisms, with the most important attribute that it has prospered and evolved and continues to be relevant and world-leading. The three principles established in our early years of being scientifically integrative, solutions-orientated, and socially interactive remain core to all our activities. Here in this brochure, we invite you to read about some of our people and their achievements.

Since the founding of Tyndall Centre, climate change research has developed to be mainstream and a core, cross-cutting dimension of academic research, rather than an add-on or uncomfortable bedfellow within traditional siloed disciplines and funders’ missions. The example of the Tyndall Centre was fundamental in this transition by demonstrating how climate change and the issues it raises could be rigorously and usefully analysed and addressed. In our impact on wider society, the Tyndall Centre has also been extremely successful, helping the policy and public dialogue to move from ‘what is climate change?’ to ‘what can be done?’ and the broad consensus that responses are needed.

Our focus is rigorous, evidence-based problem-solving, where we work with stakeholders to make sure their knowledge and experience shapes our work. This ensures that our analysis and outputs are useful and usable, underpinning our societal impact.

Many hundreds of researchers have been part of the Tyndall Centre family over the last 21 years and have influenced, and continue to influence, academia and wider society. The Tyndall Centre today is a coalition of the willing experts across its four core partner universities.

Prof Bill Clarke again, “...under the best of circumstances it will require a decade or more of active learning-by-doing and capacity building before a venture of this magnitude and difficulty can be reliably judged to have succeeded.” Has the Tyndall Centre experiment succeeded? Certainly, we have supported change and new ways of understanding and tackled some of the key climate change topics, but there is still much to do. While consensus on the need for action is the highest it has ever been, how to translate that desire into urgent action that is sustainable and just provides an important focus for our research in the coming decade.

The Tyndall Centre’s 21st Anniversary coincides with the COP26 UN climate change summit in Glasgow, postponed from 2020 because of COVID-19. Among other attributes, the pandemic has shown what science and society can achieve together. We dedicate this collection of research stories to all of the members of the Tyndall Centre that have gone before, to our present community of researchers, and to its future members who will continue to strive to be Truly Useful.

Tyndall°Centre
for Climate Change Research

Robert Nicholls, Carly McLachlan, Asher Minns
Director, Deputy Director, Executive Director

Truly Useful
21 YEARS

“The Tyndall way of working rapidly became the international role model for interdisciplinary climate change research that is academically rigorous and relevant for policy and practice.”

Bringing aviation and shipping into the climate change debate

Professor Alice Larkin

Professor in Climate Science and Energy Policy at the Tyndall Centre for Climate Change Research, University of Manchester

Aviation and shipping are now a crucial part of the debate around climate change and the drive towards net zero. But the journey towards this has been far from smooth. Policymakers tend to focus on nations and their activities, and as emissions in these sectors are released into international air space and waters and are not any one country's responsibility, these areas have tended to be overlooked. One of Tyndall's many achievements has been to highlight the fact that they cannot be ignored when it comes to reducing CO2 emissions.

I was recruited as a post-doc to do some research around aviation. Friends of the Earth and some other groups were interested in this area and we secured funding which allowed us to examine the European, as well as the UK, picture. We ran stakeholder workshops with easyJet, Airbus and other interested parties, including government policymakers, and looked at the scope for a reduction in emissions from air travel. Aviation is more simply structured than shipping, with just two dominant manufacturers, but the technologies and designs are typically more mature. Aircraft are efficient, well-designed and use advanced materials, such as composites. There is the option of alternative sustainable fuel, but this will take many years to become available in the quantities needed to offset growth, so it is essential we interrogate the demand – the volume of flights and the distances being travelled. In short, if aviation is to play its part in achieving the Paris targets, it is going to be about reducing flights, not decarbonising aircraft.



This was a message that attracted widespread media coverage and protestors at Heathrow Airport's Climate Camp were photographed with our report taped to their bodies. Our research was also submitted to government select committees and contributed to aviation being included in the European Union Emissions Trading Scheme, the first and largest greenhouse gas emissions trading scheme in the world and a major pillar of EU energy policy.

The Heathrow third runway expansion policy passed by the UK Government was rejected at judicial review because of the conflict between the expected aviation emissions growth our research had identified and the ambitions of the Paris Agreement. Additionally, the Manchester Climate Change Framework has adopted aviation climate policies as the result of our input. This has reduced investment and policy risk for business and local government by recognising this source of emissions in subsequent spatial and economic planning, and therefore avoiding the need for late and costly responses.

Tyndall also secured funding for several shipping projects, some focused on the UK, others internationally, and which drew contrasting conclusions. Here, there were lots of available technologies which could be used to decarbonise the sector, including wind propulsion, slow steaming and Flettner rotors. We analysed how quickly shipping might need to reduce its emissions and what the potential options might be. In 2018, as a direct result of findings developed with colleagues at University College London (UCL), the International Maritime Organisation (IMO) set a global target to reduce shipping's CO2 emissions by 50% by 2050. In 2021, we hope to be using our latest research to support the IMO in aiming higher. So, Tyndall has played a significant role in the setting of targets which are in line with the science.

In terms of Brexit and Covid, it is too early to know what the long-term impacts might be on travel. Business travel is a relatively small proportion of air travel – typically about 12-14% – and some change in business flying habits does seem likely. Universities are by their nature international, attracting foreign students and encouraging researchers to build international networks, but debate is now starting about the flights taken for education and research. Being able to take part in international meetings virtually is seen as a real positive by some, particularly from an equality and diversity perspective. Nevertheless, we have to make the alternatives to flying much easier and more affordable if we are to see a reduction.

Building on our earlier work, our colleagues looked at the social practice of frequent flying with a key learning that people wouldn't want to miss their annual holiday or be penalised for seeing friends and family. But there were other flights they could potentially forgo. So, a challenge facing social science is how you develop policy that doesn't penalise people for taking their annual holiday and travelling to see family and friends, but tackles things that are somehow 'more trivial'. This is something that a frequent flyer levy, as discussed at the recent Citizen's Assembly, might be able to address. However, if we don't encourage and support people to do things differently, we stand to lose the current opportunity that we have to drive down CO2 emissions in aviation.

I worry that too much store is still being put on new technology and aviation growth is not being curbed, with Southampton Airport's expansion having been green-lighted. Although electric aircraft are being developed now, they will be small and for short-hop flights, and will not deliver an alternative to combusting kerosene on most mainstream flights in timeframes compatible with Paris goals. As for alternative transport solutions, the HS2 programme is rarely discussed in terms of the potential reduction of short-haul flights within Europe by, for example, connecting the north of the UK with Mediterranean cities. Rail is incredibly low-carbon, and journeys from 'The North to the South of France' would be appealing.

Tyndall has paved the way for research organisations to sit comfortably in that space between policymakers, stakeholders and academic research. This is common practice today, but we were one of the first organisations to actively support that type of academic work. You can't join the Tyndall team and stay in your own narrow discipline. Your mind is quickly opened out to different perspectives that you need to take into consideration, ultimately making the research we do so much more impactful.

Harnessing the potential of bioenergy

○ **Andrew Welfle**

Researcher of Bioenergy, Sustainability, Climate Change and Energy, Tyndall Centre for Climate Change Research, University of Manchester

Ask most people to name the UK's number one renewable technology and few would guess the answer. Solar and wind tend to make the headlines and dominate the front covers of scientific reports, but bioenergy produces the most energy in this country, contributing 31% renewable electricity, 83% renewable heat, and 5% total transport energy. Not everyone is comfortable with that because they don't want to cut down trees, but bioenergy comes from all kinds of other resources and the UK Government has strong ambitions to increase bioenergy as part of its industrial strategy and climate change commitments.

Rewind 20 years and we were still wedded to coal. Regulations were gradually introduced to support cleaner alternatives and some of the coal producers started converting their large power stations for the burning of wood pellets. Initially, it was 50/50 coal and wood pellets, and now they have made the full transition. However, as the UK was sourcing a large proportion of pellets from countries such as Canada, stories were appearing in the press suggesting that pellets were in fact dirtier than coal.

At University of Manchester (UoM), we developed a way of calculating the life cycle impacts of that process. So, that's everything from growing a tree, managing it, cutting it down, putting it on a lorry, turning it into pellets and shipping it. A lot of the wood being used by the energy company Drax is from trees that are diseased and wood that needs to be thinned. If you think of forests as a system, they are pretty efficient because they lock up carbon, but there comes a time when a tree gets old and dies. So, we need a system where there is a continual growth of trees and when trees die, that carbon is captured, stored and used, something the Tyndall Centre is doing a lot of research around. If you can take that wood, produce energy from it and capture the carbon afterwards, from a greenhouse gas lifecycle perspective that beats hands down every other renewable technology.

For my PhD, I came up with a model that was able to calculate the amount of potential biomass we have in the UK. I then looked at what types of energy could be generated from that resource and how that energy could be matched up with the UK's targets. This resonated with policymakers who were asking lots of questions around how much biomass resource existed and how bioenergy and biofuels could support decarbonisation, particularly for our power, heat and transport sectors. We certainly don't have sufficient biomass resources to provide for every energy scenario, so a lot of the work I did was around how we could best use those resources and how we could source biomass in a sustainable way to further increase our bioenergy potential.

Through a Knowledge Exchange Transfer, I had a spell working with the Department for Energy and Climate Change (DECC), which had just developed a new methodology for calculating the greenhouse gas performance of bioenergy. I did over 2,000 calculations using different resources and technologies and in the vast majority we were able to show that we could produce low carbon energy from biomass resources on our own shores. My time there also coincided with an assessment of the RHI [Renewable Heat Incentive] scheme and our science greatly influenced the refocusing of that policy to prioritise heat bioenergy generated from UK waste materials such as food wastes or materials generated by agriculture. Our work influenced a policy change which resulted in an 84% uptick in heat energy generated from wastes. UoM research also helped secure an additional £110m from the Treasury to extend the RHI scheme and develop future renewable heat support schemes. Although much of my research is around forestry, my work for DECC focused more on the organic materials from everyday life which so often end up discarded or in landfill.

We might think of the UK as a small island with not much land or forestry. But we do have a significant agricultural sector and plenty of industry and we have good infrastructure systems and sewage networks in place, so we can collect all these things. It's just a case of connecting the dots and making better use of what we've got.

If food waste can be taken to centralised locations and put through anaerobic digestion systems, you can produce a biogas which is about 50% methane and 50% CO₂, and you can separate those out relatively easily. You can then burn the biogas onsite as it is or, if you want an upgraded fuel, you can clean it and reduce the CO₂ content. If you are using anaerobic digestion on a large scale, you can inject that straight into the national grid as it is chemically the same stuff.

Bioenergy is mainly used to produce electricity in the UK, but other renewable electricity technologies are coming online which should leave biomass resources available to produce heat and transport fuels. The Department for Transport would love to use all the resources available to produce fuels for cars and aviation. But if you speak to someone in BEIS (Department for Business, Energy and Industrial Strategy), they may argue that the best use for resources is for the generation of heat. Resources are finite and people are only just starting to make decisions on how to best use them. The critical role played by the Tyndall Centre has been to provide the science used to underpin the UK's bioenergy strategy, which has laid the foundations for growing a sustainable bioenergy sector and wider bioeconomy. By working in partnership with industry, NGOs and Government, our research has promoted a greater role for bioenergy and demonstrated how our existing biomass resources can best contribute to our carbon reduction targets.

Informing policy for a greener Brexit

Professor Andy Jordan O

Professor of Environmental Policy at the Tyndall Centre for Climate Change Research, University of East Anglia



When the EU Referendum was originally mooted in 2013, very few people fully appreciated how deeply the EU had Europeanised UK-wide environmental and climate policy. So, it was only in the days after 23 June 2016, when Britain voted to leave the EU, that the full enormity of the policy choices that lay ahead began to dawn. Sir Jeremy Heywood, while head of the UK civil service, famously described Brexit as the “biggest and most complex challenge” Whitehall had faced in peacetime. The steepest of learning curves has certainly followed that momentous decision and the reverberations will be felt for many years.

Long before the referendum, the Tyndall Centre had, however, been engaged, contributing to the 2014 Cabinet-led Balance of Competences Review, the largest stocktake of Europeanisation ever undertaken by an EU member state. Its submission, led by me, influenced the context in which the environmental sector prepared for and participated in the referendum. I was cited many times in the Environment/Climate Change chapter. When the referendum was announced, I teamed up with Green Alliance, a leading UK environmental charity, and the Economic and Social Research Council's UK in a Changing Europe impact initiative to spearhead a systematic review of academic research. This directly informed the position that the large environmental NGOs adopted in the referendum campaign.

In the wake of the result itself, I was involved in the creation of Brexit&Environment, a thinktank that quickly established itself as the 'go to' destination for impartial, authoritative research on the environmental implications of leaving the EU. With associates located across the four UK nations, it offers a uniquely UK-wide perspective and has produced influential knowledge reports for several organisations in government, in many parliaments and in the charity sector.

Within days of the result, Professor Charlotte Burns (University of Sheffield) and I were invited to advise the influential House of Lords EU Energy and Environment Sub-Committee on the timing, content and scope of future inquiries. The evidence we provided significantly shaped many of its subsequent reports. For example, it was cited in the very first page of the Committee's 2017 report *Brexit: Environment and Climate Change*. Other influential bodies quickly took note of what we had said and the large cross-sectoral NGO coalition – Greener UK (which was headquartered in the Green Alliance) – switched its tactics. Very soon, it became clear to the sector that a new watchdog would be needed to hold the UK government to account and that the environmental principles should be embedded into UK law, via the EU Withdrawal Act. These soon became Greener UK's main campaigning objectives.

Under sustained pressure from their Lordships and Greener UK, the Secretary of State, Michael Gove, eventually announced a slew of new policy proposals. These included: a new Environment Act; a new national environment watchdog for England and Northern Ireland; measures to embed EU policy principles in UK policymaking; and a new system of long-term target setting and policy planning – building on the 25 Year Environment Plan. These proposals were enacted in two flagship bills. In time, Scotland and Wales made similar announcements, marking a once in a generation change in UK-wide policy and governance.

With Brexit, the environmental NGO community has had to fight hard to stand still; stopping existing protections from falling away rather than adding new protections has been a trial of strength. Tyndall's research dating back over 20 years provided the intellectual justification for these changes. It revealed that a great deal of UK environmental policy had been developed at EU level by EU bodies and/or EU specialists based in the UK and then cascaded down to Westminster and Whitehall to debate and roll out. The referendum has, in turn, generated a demand for new research. This research is revealing that since 2016, new policy development outside the framework of the EU is very resource-intensive. Defra is approximately double the size it once was, and the NGOs have had to learn to work together more constructively essentially just to hold the line.

Tyndall also realised relatively early on that Brexit would have important implications for UK devolution. When the UK was a member state of the EU, the devolved administrations (Scotland, Wales and Northern Ireland) essentially had to follow the same EU-lead approach as England. Remove the EU from the equation and the devolution of environmental matters, which had occurred slowly since the late 1990s, could not only accelerate, but proceed in unexpected directions. Crucially, after Brexit, the devolved administrations have greater scope to deviate and, within limits, go in their own direction. Brexit&Environment's 'all of the UK' coverage has paid dividends in terms of being able to understand and inform how Brexit plays out across the four nations.

The new national watchdog should have been in place at the end of the transition. So, the fact it won't be fully in place until the end of 2021 means there is nobody to oversee the implementation of all the rules we inherited from the EU. It will mean there is no UK body overseeing the implementation of the 25 Year Environment Plan, which was an element of the Government's pledge to leave the environment in a better state than we found it. It also means the UK lacks the capacity to check that the EU is implementing its commitments post-Brexit.

For me, the Tyndall Centre has always had a practical 'can do' mentality which I've tried to apply to understand and inform Brexit. Structural changes in academia have, of course, also played a part. Over the last 20 years, there has been a pronounced shift away from science for its own sake to what is increasingly termed Impact. In many ways, Tyndall (and UEA more generally) has been well ahead of the curve. For example, like many of the core partners in the Tyndall network, Environmental Sciences at UEA performed incredibly well in the 2014 Research Excellence Framework (REF), ranking top in the country for environmental Impact. The challenge we now face is to do Impact work which is not only 'truly useful' for future REFs, but for wider society.

From long-term targets to immediate local actions

Professor Carly McLachlan

Professor of Climate and Energy Policy, Director of the Tyndall Centre for Climate Change Research, University of Manchester

Collaboration and engagement with local communities has long been part of Tyndall's DNA – something to which Manchester can certainly bear witness. Our work with Greater Manchester Combined Authority (GMCA) and other stakeholders has resulted in carbon reduction targets being set for the city which are compliant with the Paris Agreement. As a direct result, five major city regions have adopted new, ambitious strategies on climate change, and this in turn has shaped the operating approach of public and private sector organisations in those areas.

Tyndall research has led to a shift in focus from long-term 2050 targets to immediate actions to cut emissions in the climate change plans of local authorities covering around 18% of the UK population. In a single combined authority, our work has shaped plans that include £40bn of investment over 20 years. Our Local Carbon Budget Tool is being used by 250 councils and has been approved for inclusion in the United Nations' Race to Zero initiative.

These achievements are all the more extraordinary given the humble beginnings of our work in Greater Manchester. Tyndall received just a few thousand pounds to assist the combined authority with its performance around carbon emissions and future planning. We had a long history of working with the authority and this piece of work helped us see that a tool to help set a local carbon budget and develop pathways towards meeting that budget would really help officers, councillors and stakeholders across the city.

Working collaboratively with GMCA and consultants, Anthesis, we were funded by the Department for Business Energy and Industrial Strategy (BEIS) to set up the SCATTER project (Setting City Area Targets and Trajectories for Emission Reduction) for the UK Core Cities. When we began getting requests for our local carbon budget methodology from other parts of the country, we were awarded additional funding from the EPSRC (Engineering and Physical Sciences Research Council) Impact Acceleration Account to make it more widely available.

To deliver action on the scale required, you need coalitions of stakeholders. In Manchester, there are five 'Challenge Groups' involving hundreds of colleagues all feeding in and trying to support the transition in whatever way they can. We have recently established the Energy Innovation Agency to bring partners together to accelerate our drive towards a Net Zero energy system. We want to be able to experiment, innovate, learn and deploy within Greater Manchester and beyond. This might require, for example, derogations from Ofgem so we can try different things in the energy system or getting large estates on board to try new technologies in their buildings. We believe we are much more likely to deliver rapid transformation of our energy system locally if we combine the strengths of three universities, the Combined Authority, Bruntwood, and SSE, as this partnership gives us more scope to learn and upscale our successes.

Through CAST (Centre for Climate and Social Transformations), we have continued to discuss with GMCA how in its city-level decision-making it could take a co-benefits approach to accelerating climate action. As part of that, we are building a decision-support tool that will be applied to all its key decisions from May 2021. That tool won't be perfect by any means, but the need is urgent, and we are working with them to take an iterative approach so that we start making significant improvements in terms of the outcomes and impact of decisions now. Cities and local authorities are exciting scales to work at because there is a lot of opportunity to get stuff done. We can also come together across a wide range of stakeholders and amplify our voice to national government to call for the changes and support we need to hasten our response.

Tyndall's reputation for impactful research has also led to an unexpected and exciting piece of work with the band Massive Attack. They want to reduce the carbon footprint of their tours and we were recommended to them as a potential partner to approach. The great thing about working with them is they are so knowledgeable about energy and climate change and very honest about the environmental impact their work has had over the years. For a US tour pre-Covid, they travelled up and down the west coast and east coast by train and that did lead to a significant reduction in their carbon emissions.

Getting to Net Zero without any negative emissions or offsets doesn't feel very feasible because you are still going to use aviation to get musicians around some parts of the world. But there is scope to improve it. You might want to look at how often you do that and how long the tour is. You can take fewer people, take less gear with you and, where possible, travel by different modes (e.g. trains rather than planes). We have been looking at the degree by which you use a 'house rig' for your lighting and the potential for a more collaborative approach to that. On some tours, artists and groups are sourcing equipment locally rather than transporting it to different locations. So, there is already a precedent for doing it differently and there is a lot of good will in the industry.

For the Tyndall Centre, it is about wanting to influence policy and action and building these collaborations to ensure what we are doing is useful for them. We do have critical conversations and sometimes we are often saying people need to go further and faster than they are currently planning. However, we need to see their perspective and speak to their own contexts if we really want to accelerate action.

Communicating climate change – context matters



Jordan Harold ○

Cognitive Psychologist, School of Psychology,
Tyndall Centre for Climate Change Research,
University of East Anglia

Although more and more people are aware of climate change and view it as an urgent issue, this has not yet translated into the scale of behaviour change needed to meet the challenges. Behavioural shifts in diet, housing, travel and the consumption of material goods are needed. Much of the discussion of these behavioural shifts has focussed on how individuals will need to change their habits and make different choices. For example, eating less meat, swapping out gas boilers for heat-pumps, and flying less. However, these behaviours are shaped and constrained by the contexts in which we live. We therefore need to understand and change the contexts in which our behaviours are situated.

These contexts are largely outside of any individual's control – they are shaped through the communities, organisations and societies that we are part of, and interact with. Behaviour change is therefore not just about changing our individual everyday habits and choices, it is also about bringing about social change by influencing others. Key to this is communication.

My work looks at how science, in particular climate data, is communicated through visuals. Here at the Tyndall Centre we really understand the importance of interaction and co-production with society. An example of this is the Tyndall Centre's work with the Intergovernmental Panel on Climate Change (IPCC), whose reports help to inform governments' climate change policies.

Although IPCC reports contain summaries that have global reach, they are not designed for Presidents and Prime Ministers, nor for the public. Instead, the summaries need to go through another layer of translation before they achieve the level of clarity needed for these audiences. Yet there is also broad societal interest in these reports, which are often accessed by individuals and organisations tens of thousands of times within days of release. Those individuals and organisations will not have an IPCC expert to unpack and interpret what it all means. So, there is a real opportunity to simplify the summaries.

One way to do that is to use visuals that convey the key messages of the report and are easily understood. Although these summaries are aimed at policymakers, I would like them to become summaries for citizens that are readily accessible to everyone in society. This is of course an ambitious vision – reports must retain their scientific rigour and their content must be agreed by consensus between the scientists and 195 governments. In other words, you can't just 'dumb down' the reports.

The Tyndall Centre, supported by the Norwegian Environment Agency, approached the IPCC and offered to provide advice and support to assist in the creation of more accessible visuals. Our inter-disciplinary team of psychological and social scientists undertook research into how IPCC visuals are used, and published recommendations on how they could be made accessible to wider audiences.

We produced the MADE Report, which takes a really simple approach. The idea was to come up with a way of articulating best practice and guidance for the scientists writing the reports. 'M' is work out what your Message is; 'A' is understand your Audience; 'D' is Design it using cognitive principles about how people process information, and 'E' is for Evaluate as you go. The MADE guidelines have been adopted by the IPCC and used during the preparation of high-profile reports such as the Special Report on Global Warming of 1.5°C and the Special Report on Climate Change and Land.

We also worked with Future Climate For Africa, a research and development programme that aims to generate new climate science focused on Africa. We looked at the different methods it was using to communicate uncertainties in climate projections, ranging from scientific graphs used with city planners through to participatory games with local farming communities in which future climate scenarios are role-played. These approaches really demonstrated the value of tailoring communications to the societal contexts in which people make decisions.

When it comes to communication aimed at bringing about change, context matters. To borrow a quote, "We are always embedded in a place. In fact, we are always nested within layers of place, from a room, to a building, to a street, to a community, to a region, to a nation, and to the world."¹ For me, The Tyndall Centre is truly useful because we operate within, between and across these layers – putting science into practice not for society, but with society.

1. Gifford, R. (2014). Annual Review of Psychology, 65, 541–79.

Preparing our infrastructure for climate change

Tyneside and the surrounding region were rocked on 28 June 2012 by a storm which wreaked devastation and left thousands of people without power. 'Thunder Thursday' or the 'Toon Monsoon' saw a month's worth of rain fall in about two hours and key structures like the Tyne Bridge struck by bolts of lightning. In the winter of 2013/2014, a series of severe storms hit the UK, leading to widespread flooding and a major emergency response. The impact prompted then Prime Minister David Cameron and national media to attribute the events, at least in part, to climate change.

Extreme weather events are becoming more frequent and the threat they pose to essential services, such as water and energy supplies and transport, is growing. Assets and networks across all infrastructure sectors are already exposed to multiple sources of flooding and networks near rivers, especially bridges, electricity and communication cables, and gas pipelines, will need protection from higher flows and erosion of bridge foundations. Preparing and adapting to changing weather as cities grow and evolve will help mitigate the effects of climate change and increase the resilience of urban environments today.

Professor Richard Dawson

Professor of Earth Systems Engineering and Director of the Tyndall Centre for Climate Change Research, Newcastle University

Tyndall Centre scientists at Newcastle University developed a geospatial modelling platform which now underpins the world's first infrastructure 'system of systems' analysis and was used to develop the UK's first National Infrastructure Strategy, including £320bn of planned investment in infrastructure up to 2020/21. This modelling capability brings together data on infrastructure networks and the flow of resources about those networks, so you can start to understand how energy supports transport, housing, and other infrastructure sectors. This is something which can be used in different locations because it is designed to handle infrastructure data and networks. This pioneering work, which led to development of the first National Infrastructure Database, not just analysed individual infrastructures at a national scale but looked at vulnerabilities that emerge from connections between infrastructures. For example, how a loss of power can bring down an airport or a railway line. As we move towards Net Zero, where everything is reliant on electrification, the risk of that interdependency is going to grow.

My own work on sustainable cities began when I became the lead research fellow on the Tyndall Centre Cities Programme, and we developed the first local climate risk analysis and integrated strategy for adaptation and mitigation. Focused on London, it brought together a wide range of different climate impacts and looked at how socio-economics and climate might play out and what that meant for all these risks. Individual risks had been assessed before at this city scale, but this was the first time lots of different risks and their interplay with decarbonisation strategies had been looked at together. The conclusions fed into the Great London Authority's Adaptation Strategy and Water Resource Strategy and I was seconded there briefly to help facilitate those discussions.

Mitigation and adaptation often interplay in cities. The transport choices we make influence greenhouse gas emissions. In turn, how we choose to protect that transport infrastructure from flooding or heatwaves, and how we configure our cities more generally, influences the transport we need. Not many people live in London's business district, so lots of people commute. So, a more distributed, mixed-use model where people can live and work close to each other would reduce the amount of travel that people do and the carbon emissions from that. But the risk of flooding would be different. The opportunity of disruption to travel would be limited because you don't have to travel so far, and as we move towards Net Zero and the electrification of cars we see that we are essentially introducing a new layer into our infrastructure, with charging points and higher voltage power systems within our cities. Damage to those could have knock-on risks to transport.

Prior to my work on cities, I was involved in research about the impact of rising sea levels and flooding on coastal areas, specifically in Norfolk. This project garnered a lot of attention and was also influential. A decision had been taken by the Government not to replace the structures protecting the cliffs at Happisburgh, which were being washed away. Usually, sediments from the cliffs move along the coast in a particular way and because the cliff wasn't naturally eroding, they weren't coming down. We were able to show that those sediments gave a huge amount of flooding protection for the Norfolk Broads and the economic benefits they provided were far more significant in terms of flood protection than they were in terms of coastal erosion. The paper arising from that research won the Lloyd's Risk Prize and we turned it into a book, *Coastal Risk Management In A Changing Climate*.

Thanks to Tyndall Centre's international leading research, infrastructure today is better prepared for climate change, transforming the design of adaptation strategies for water, transport and energy infrastructure. Our provision of improved projections of future climate is now embedded in industry guidance, while government has implemented our new decision-support approaches to ensure that resilience to these changes is considered in all government infrastructure spending. Initially demonstrated in the UK, Tyndall research has subsequently informed climate policy and investments internationally.

Response to Covid-19 will have lasting impact on emissions

Professor Corinne Le Quéré

Royal Society Research Professor of Climate Change Science at the University of East Anglia and former Director of the Tyndall Centre for Climate Change Research

Every year the Global Carbon Project publishes data on carbon dioxide emissions from fossil fuels, emissions which must rapidly fall towards zero if we are to reduce the risk of dangerous climate change.

Most countries have committed to pursue efforts to limit climate change to 1.5°C of warming and achieve a balance between the emissions and removals by sinks of greenhouse gases as part of the landmark intergovernmental Paris Agreement on climate change. However, much stronger policies are going to be required to ensure emissions peak and fall more quickly.

Research conducted by the Tyndall Centre contributed to enshrining these objectives into the Paris Agreement, showing that they are possible and by what means. It supported the translation of global objectives into national Net Zero emissions targets in the UK and France, while supporting similar reflections in the European Union and worldwide. In addition, our research and engagement with policymakers at national and international levels has been instrumental in setting Carbon Budgets and climate change targets via international agreements and national laws.

Through its role in the annual publication of the Global Carbon Budget, Tyndall has helped create a consciousness that anthropogenic emissions and sinks need to be balanced if we are to tackle climate change and increase the scientific understanding around this. Countries have agreed through the Paris Agreement to achieve a balance between carbon emissions and removals by sinks of greenhouse gases and our research contributed to that. Each year, the Carbon Budget receives extensive press coverage and that exposure recently reached two billion people. Eminent figures who have used our research include former Bank of England Governor, Mark Carney, UN Secretary-General António Guterres, and former UN Chief Executive Christiana Figueres. Canadian author and social activist Naomi Klein also cites the research in her book *This Changes Everything: Capitalism vs. the Climate*.

Tyndall's research helped inform the UK's Climate Change Committee's target for Net Zero and the targets set by France. I also led a consultancy project with BEIS [Department for Business, Energy and Industrial Strategy] where we designed work and training for civil servants and contributed to Government thinking.

More and more you really need to be connected to policy circles so your research and findings are actionable. In my experience, most policymakers want to do good, especially those that specialise in climate change. They want actions to work. So, our research needs to address how climate actions could work in practice and what institutions and individuals can do to help make effective decisions. For your research to be helpful, you need to understand where people are coming from. Timing is also a big issue. Research is rather slow and policymakers often come up with questions you have not even thought about. So, helpful climate-related research is about developing the capacity to do serious, productive, detailed research, but also the flexibility to give additional insights based on the questions that arise at the time.

You can do these things when you have the support of interdisciplinary colleagues and institutions that are at the forefront of issues like this and able to inform policy discussions. By training I am a core physical scientist, and the Tyndall Centre has totally broadened my horizons and enabled me to do research in a much broader, social context. It also helped me understand the true human drivers of carbon emissions. The Paris Agreement was signed in 2015, so the years leading up to that were crucial in terms of communicating science and doing research in the context of a very active policy environment. After the Agreement was signed, it was then about responding to how we implement it.

When the Covid-19 outbreak happened, we realised very quickly it would seriously impact our response to climate change. In terms of reducing emissions, measures imposed during the Covid-19 crisis will have little effect on climate because they are temporary behaviour change measures rather than long-term investments. But how governments respond to the pandemic will have a lasting effect. In particular, what they put in their recovery plans, the extent to which they consider climate dimensions, what investment they make in infrastructure. For example, if they invest in roads but not cycle paths in cities, it will make a huge difference as to whether people will be encouraged to cycle or drive to work. In May 2020, I published a peer-reviewed paper which effectively said to decision-makers, 'We know that things are going fast, but make sure your decisions fall within the umbrella of climate actions or the emission consequences will be dire.'

Although behaviour change does contribute to climate change, the effect of that alone is not that significant. If we took all the climate actions that we could as individuals, we might achieve about 25% reduction in our own carbon footprint, and that's being generous. What we really need is for countries to invest in cleaner alternatives, so we move away from petrol cars towards electric vehicles and other forms of mobility, and away from gas heating systems to heat pumps and so on. Governments need to make it easier for people to make low-carbon choices. So, while Covid-19 does present some opportunities, it's really what the Mayor of London or Manchester does to facilitate clean mobility in those cities that will make a big difference to emissions and tackling climate change.

The psychology of environmental behaviour change

Professor Lorraine Whitmarsh

Director of CAST (Centre for Climate Change And Social Transformations), University of Bath, Affiliate Member of the Tyndall Centre Partner Institution

Covid has radically changed our behaviour and, in turn, our carbon footprint. We have worked remotely from our homes, cooked more and wasted less food, and taken fewer car journeys and flights. The restrictions imposed on us by government and senior health officials have also given us time to reflect on how the decisions we take as individuals impact on the environment. Time will tell whether some of the new behaviours we have adopted during lockdown will continue beyond the pandemic and contribute to a lasting reduction in carbon emissions. What is clear is that if we can capitalise on these shifts in behaviour and this increased awareness of climate change, we can make valuable gains in the drive towards a low-carbon sustainable future.

Research has tended to focus on governments and industries and on the technological, demographic, and economic trends that drive climate change, overlooking factors that influence personal decisions and lifestyles. However, our behaviour informs societal change via adoption of technologies, use of resources, support for policies and actions in the workplace and communities, and unless we examine the things that influence mitigation and adaptation behaviours and how climate change will affect wellbeing, we will be unable to respond effectively as a society. Community preparedness can be improved by considering these processes in the design of education and messaging, but also wider policies to encourage and enable sustainable behaviours. So, we need to develop effective ways to integrate psychological research into these efforts and our broader understanding of human interactions with a rapidly changing climate.

Since the outbreak of Covid, we have been tracking people's habits and their attitudes to climate change and to what extent they might stick as restrictions are eased. Virtual communication has replaced everything from business travel to medical appointments and exercise classes, drastically reducing air and road travel. Being at home and with restaurants closed, there has been a shift from eating on-the-move towards more batch-cooking of food and the using up of leftovers. Consequently, we have seen a marked decline in food waste, which is great. There has also been a change in our energy usage, with people taking fewer showers, and spending their time in low-carbon ways, such as gardening or engaging in creative activities.

Getting people out of cars is such a win-win and Covid has forced us to ask ourselves why we drive so much. I am optimistic that working from home and the resulting reduction in business travel will continue to some degree. We clearly have the technological capabilities for remote working and from an employer perspective we are seeing office floor-space reduced, and employees being encouraged to work from home, at least for some of the time. As a result, some of our new food behaviours may also become habitual.

During the first lockdown, when we asked people about air travel, they said they were more likely to reduce than increase their flying. But that had shifted slightly when we polled the same people again in late October, so we might see some rebound when travel restrictions are eased. CAST also conducted a study, coordinated by Cardiff University, that showed climate change scientists and researchers did more flying than those from other scientific fields. It was shocking that those who were the most knowledgeable about climate change were, in their professional lives at least, clocking up the most air miles.

We know that during times of disruption you can intervene and change people's behaviour and Covid has presented such a window of opportunity.

The Government has made some encouraging announcements and at a more local level employers are starting to see the benefits of a 'green recovery'. Local authorities have also had emergency funding to encourage people to walk and cycle in cities, which is partly about having more space between people, and also about air pollution. This is being used to develop more low-carbon neighbourhoods and if this can be implemented now, it will help to lock in those behavioural changes we have seen during the pandemic.

Effective change requires working with people to understand their values and needs and the Tyndall Centre has been a pioneer in terms of engaging with the public on climate change. I joined Tyndall as a post-doc about 16 years ago and I have seen first-hand the impact it has had. It has grown a whole cohort of young researchers who are uniquely enthusiastic, positive, collegiate, and keen to make a difference and tackle climate change. As well as developing their careers, researchers feel they have the skills to engage with people away from academia. Back in 2008, two researchers created a '2050 Garden' at the Chelsea Flower Show in London, which explored plants and practices in a changing climate. It was absolutely beautiful and attracted a lot of attention and comment.

Tyndall was really at the forefront of inter-disciplinary scientific research. Instead of having your climate modellers here, engineers here, and your social scientists there, it was perhaps the first successful attempt to combine those different disciplines and focus on how we can sustainably tackle climate change in a way that does not make things worse in terms of poverty or biodiversity. That inclusive, joined-up approach to research has meant that Tyndall has so often been able to address the questions policymakers and other key decision-makers need answering.

Mitigating climate change's rising threat to nature

Professor Rachel Warren O

Professor of Global Change and Environmental Biology at the Tyndall Centre for Climate Change Research, University of East Anglia

Covid has many lessons for us and our world and perhaps the most powerful of these is that we mistreat nature at our peril. There are about one thousand other zoonotic diseases waiting to jump into humans and we must learn to respect nature if we are to avoid the triple crises described in the *Making Peace With Nature* report that I co-authored. We naively believed we had eradicated the threat of global pandemics, but they are now happening again and there are two reasons for this. The first is globalisation in air travel, which means as soon as there is a disease it quickly spreads across the world, and the other is our increasing exploitation of nature.

As is widely known, humans are also causing global warming, which also affects nature. My colleague Jeff Price brought together the Global Biodiversity Information Facility (GBIF), James Cook University in North Queensland, and myself at the Tyndall Centre to form a collaboration called the Wallace Initiative, whose purpose is to study how global warming affects biodiversity and how we can address this. GBIF has data about the places on earth where each species is currently found. Every species has a preferred climate envelope in which it likes to live and an optimal temperature they find most comfortable to live, and most importantly, to reproduce in. If a species tries to thrive in an area where it is not suited, it may not survive, or it may be outcompeted by species that are more fit to live in that environment. Climate change is now happening at such a rate that species are struggling to keep up and find places where they can survive.



What the Wallace Initiative did was to quantify the extent of that problem and we used a statistical model to find the preferred climate for each of these 120,000 species. We used the GBIF data for species where there were at least 40 data points indicating where the species has been observed. We know what the climate is like now in each of those places. That enables us to create equations that tell us where else we would expect to see that species right now, i.e. where else has the right climate. So, we can create a map of where the climate is suitable for the species right now. Next, we use our climate models and add the projections of climate change to the currently observed climate.

That gives us the new climate, showing how it has changed due to global warming. We then use the species equation to look and see where the climate is still suitable for the species after the planet has warmed by 2°C. This gives us the new envelope for that species in a 1.5°C warmer world, which is a significant number because under the United Nations Paris Agreement, nations have committed to limit global warming to 'well below 2°C' and to 'pursue efforts' to limit warming to 1.5°C. We can then look at how fast we think the species can change its distribution and say whether or not we think the species is going to keep track of the changing climate during this century. We then repeat the process for 2°C, 3°C and 4°C of global warming.

The findings we made about the proportion of species that would lose more than half their geographic range were as alarming as they were significant. An assessment of the pledges made by the nations of the world by the end of 2020 to reduce their greenhouse gas emissions (the ones that cause climate change) were only sufficient to limit global warming to 3°C.

If the planet warms by 3°C, we found that half of the insect species we modelled, 44% of the plant species, and one quarter of the mammals, birds, reptiles and amphibians, would lose more than half of their geographic range. Therefore, we are looking at a huge impoverishment of the number of species currently found in a given location if global warming is not curtailed as agreed under the Paris Agreement. More recently, nations are beginning to step up their pledges, but these steps are still nowhere near sufficient to achieve the goals of the Paris Agreement. The next UN Conference of the Parties, to take place this November, is a critical meeting at which nations have the opportunity to step up their pledges sufficiently to meet the goals of the Agreement.

People may think that insects pollinate plants, animals eat plants, and animals eat insects, and consequently there is huge redundancy in the roles that species play in an ecosystem. But that is only true for a few very generalist species. Many depend on a small number of other species and sometimes only one species, for things like food, shelter or reproduction. So, there is this incredibly complex and fascinating web, and once you start removing species from the environment, the ecosystem will basically stop functioning. That means that the ecosystem will not provide its services to humans. Many people may be unaware of these services, but they include pollination, preventing soil erosion, preventing flooding, cleaning the air, and cleaning the water. Most medicines have originally been derived from the natural world. More recently, the benefits that nature and biodiversity have for humans in terms of their mental well-being has become more readily apparent, especially during the recent pandemic.

Essentially, our study is looking at the loss of common species and the loss of ecosystem services on which we all depend. This is also true for pollinators: 50 per cent lose 50 per cent of their range at three degrees of warming, which is what countries have committed to in the Paris Agreement. So, we need to put more on the table to avoid this disaster. What we have shown is that if we can reduce warming to 1.5°C – which is the goal of the UN Framework Convention on Climate Change (UNFCCC) Paris Agreement – the risk is reduced by two thirds. It goes down to 6% of insects, 8% of plants and 4% of vertebrates losing more than half their range. Those results were published in *Science* in 2018, and with the abstract accessed 26,000 times and the paper having an Altmetric score of over 1,000, the work has had a serious impact.

Influencing international assessments has been another key area of achievement of the Tyndall Centre and I have been involved in a number of these, including the Ecosystems chapter of the IPCC's (Intergovernmental Panel on Climate Change) Fourth Assessment. I created a table that summarised the results of around 100 disparate studies and showed that above 2°C of warming, between 20% and 30% all of species studied at that time were at increasing risk of extinction.

I led the production of the "burning embers" diagrams in the IPCC Special Report on 1.5°C warming and contributed to a similar diagram in the IPCC's Fifth Assessment report. These diagrams illustrate how the risks across all the human and natural systems accrue with global warming. They have informed policymakers participating in the UNFCCC process to help them decide what constitutes a dangerous level of climate change. This helped them to think about what the level of global ambition should be in terms of limiting global temperature rise, as in the Paris Agreement.

For 10 years now, I have also led on projects for BEIS (Department for Business, Energy and Industrial Strategy), and it was for two of these focused on Pathways After Paris that I received the UEA's Best Consultancy Project of the Year award in 2019. The first project was cited in the IPCC 1.5°C Special Report and the findings were presented at UNFCCC meeting side-events. The second one focused on quantifying the climate change risks associated with 1.5°C and 4°C above pre-industrial levels for specific countries, including impacts on natural capital and countries' economies.

Since the Tyndall Centre was founded 21 years ago, it has developed one of the most globally significant research programmes on impacts and adaptation to climate change and taken a lead that has been widely followed. When I was studying at Imperial College, I was looking for a role in climate change science and I couldn't find anything in Britain. The Tyndall Centre was the first place that offered jobs for scientists in this field and now every university has someone working on it.

Enshrining biodiversity in climate change policy

For too long, the climate crisis has driven environmental debates, leaving biodiversity to take a backseat. Yet the senseless damage being wrought on nature and our ecosystems is as much part of the challenge facing our world as climate change and pollution, and the combination of the three is resulting in human suffering and lost opportunities. The solution will be found in addressing this trio of crises, not in isolation, but together.

This was the message at the heart of *Making Peace With Nature*, a United Nations Environment Programme (UNEP) report published in February 2021 that I co-chaired and which was co-authored by the Tyndall Centre's Professor Rachel Warren. It synthesises the latest scientific findings from about 25 global environmental assessments and it shows how climate change, biodiversity loss and pollution can be tackled jointly within the framework of the UN's Sustainable Development Goals (SDGs). The Covid-19 recovery plans present an unmissable window of opportunity for us to transform our relationship with nature and tackle these pressing issues to secure a sustainable future and prevent future pandemics. To fail in this task will completely undermine the efforts to achieve those SDGs.

Encouragingly, the report received an enthusiastic response. We asked the UN Secretary-General, António Guterres, if he would like to write the foreword. He agreed and asked if he could also personally launch it in New York, which he did, prior to the UN Environment Assembly. That ensured widespread publicity and since then we have given almost 30 briefings, including to the United Nations Environment Programme (UNEP) Committee of Permanent Representatives, the European Council, the European Parliament, and the UK House of Lords 'Peers for the Planet' committee.

How we present these assessments is critical in terms of the influence they can wield in the corridors of power. Assessment reports have been getting longer and longer, but they do contain brief summaries from which policymakers can get the bulk of the information they need. *Making Peace With Nature* has a 'top five' messages, followed by four pages of key messages, and uses smart infographics to illustrate the report's findings in terms of current and projected human-induced environmental change, and potential response options.



Professor Robert Watson

Emeritus Professor former Strategic Director of the Tyndall Centre for Climate Change Research, University of East Anglia

One of my key roles has been to be involved with national and international assessments. I co-chaired the UK National Ecosystem Assessment and the UK National Ecosystem Follow-on Assessment, and these had a profound influence on the UK Government. The first influenced an environment strategy the Department for Environment, Food and Rural Affairs (Defra) was producing, and the second led to the National Capital Committee. They also influenced the UK Treasury's Green Book whereby biodiversity and ecosystem services now have to be considered in all future policies.

Internationally, I chaired the IPCC, the negotiations to establish the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), and then became a member of the IPBES Bureau, first as a vice-chair and then chair. The sequence of IPBES assessments, especially the global assessment, put biodiversity on the international map, on a level comparable with climate change.

Some outstanding papers have been written by Tyndall scientists. However, the way to influence policy is through assessments. I have been a senior scientific adviser to the British and US governments and the World Bank, and it is not wise to rely on the latest individual paper for evidence-based decision-making. By considering all the papers on a particular topic, it is possible to see if the findings are robust and whether there are multiple papers all coming to the same conclusion. This is especially important at international level because assessments can provide policymakers in some of the smaller or less developed countries with confidence in what has been reported. It is crucial international assessments have geographic, gender and intellectual balance and, for biodiversity especially, representation from indigenous communities and use of local knowledge.

In terms of overall progress to date, the picture is quite bleak. None of the 20 Aichi Biodiversity Targets were fully achieved, including in developed countries. We are not on course to meet the Paris Climate Agreement target of limiting global warming to less than 2°C, let alone the aspirational target of 1.5°C, but on a pathway to 3-4°C. As for pollution, while there has been progress in developed countries, the situation has deteriorated in developing countries over the past decade.

Joe Biden is a breath of fresh air in the US, after Donald Trump. He has very quickly put together a series of executive orders to address climate change and facilitated the US re-joining the Paris Climate Agreement. But in the long-term he needs legislation in Congress, which will be far from easy. The UK Government is saying all the right things, as is President Macron in France, but we now need to see what policies and actions will be enacted. Some of the biggest multi-national companies are also starting to get the message.

Last year, the five biggest risks to business discussed at the World Economic Forum were environmental. This year, four of the five were environmental and the other was Covid, which is linked to the environment. The role played by the Tyndall Centre in national and international assessments has been absolutely pivotal. Drawing on decades of pioneering interdisciplinary research, it has helped establish the foundational principles of climate and ecosystem knowledge. It has then refined them in international knowledge exchange platforms to influence – most notably, the UN Conventions on Climate Change and Biodiversity – and translated them into UK-wide policy practices. Impacts have been repeatedly achieved by exercising leadership via pathways such as Defra, and the IPCC and IPBES, and by making influential contributions to the UK Natural Capital Committee and HM Treasury's Dasgupta Review on the Economics of Biodiversity.

Tyndall has shown that the sequence needed to bring about change is really simple: world-class science in the laboratory with modelling and field measurements, which then feeds into assessments and science policy at a national and international level.



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