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THE SEARCH FOR TRANQUILITY

EDITORIAL

The Cinderella pollutant?

It was around the turn of the millennium that Michael Meacher, the Environment Secretary, described noise as the Cinderella pollutant. Nearly 20 years on many feel it still is, because there does seem to be a perception in some quarters that people should just put up with noise and stop fussing. And yet, the World Health Organisation says that the burden of disease from environmental noise is the second highest after air pollution.

The systematic management of noise in the UK really began in the 1960s, with the advent of the Noise Abatement Act 1960, which made noise a statutory nuisance, the publication of the Final Report from the Government Committee on the Problem of Noise (the Wilson report) in 1963, and the first of many British Standards designed to assist with the assessment and management of noise. The subsequent decades have seen a range of noise-management measures in policy and legislation.

Noise is a complex subject. We hear sound and we can measure sound, but there is no such thing as a noise meter. As you will read, noise is *unwanted* sound, and it can have an adverse effect on the person hearing it. Primarily that adverse effect is annoyance, which is a subjective experience. Consequently, that means a sound that one person finds enjoyable can be intensely annoying to another person.

How we react to a sound depends on many factors. These include the type of source (e.g. transport, construction, industry, music); the level of sound that is heard; the frequency content of the sound (broadband, high pitch, low pitch or tonal); its duration; whether or not it is continuous; and the time of day it occurs. Our response also depends on what we are trying to do when we hear the sound. With such a range of factors it is not possible to identify a simple noise limit for all sources at all times.

In the 1990s, research started to show that long-term exposure to higher levels of environmental noise can increase the risk of cardiovascular disease. Consequently, although someone living close to a busy road might show no symptoms of annoyance, they may nonetheless be experiencing adverse physiological effects due to the noise.

Around the same time, policies started to emerge that sought to preserve and protect quiet and tranquil areas. This has led to a focus on soundscape and the positive management of the aural environment. You will find several articles considering this aspect of sound and noise management.

We are still learning about the effects of noise on our health and quality of life. What we do know is that the impact of noise must be properly considered in any development project so that we can optimise its management.

Stephen Turner has worked in the field of sound, noise and acoustics for over 40 years in both the private and public sectors, including central and local government. He is President-Elect of the Institute of Acoustics, and will start his two-year term as President in May 2020. The Institute of Acoustics is a professional body for those currently working in and wanting to work in acoustics, noise and vibration. It organises a wide variety of meetings for members and non-members, as well as a range of training courses.

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INTRODUCTION

Sound or noise?

Mike Potts analyses the relevance of acoustics in our everyday lives.

Sound, like air, surrounds us and affects us all every day, no matter where we are. And yet, few of us give much conscious thought to something that is so all-encompassing. Like breathing, sound doesn't demand conscious thought – we mostly go about our lives surrounded by it as passive listeners. Occasionally we seek out sounds that attract us, such as birdsong or music; and sometimes we are distracted or disturbed, startled even, by sudden or unpleasant noises. However, as soon as noise starts to disturb us significantly, we become acutely aware of it and, for some, it can become unbearable.

Acousticians generally use the word 'sound' in a neutral way but, historically, 'noise' has been defined as 'unwanted sound'. People will speak of the beautiful *sound* of a bird singing or a waterfall plunging into a pool, but the horrible *noise* from traffic or construction. This edition of the environmental SCIENTIST provides a welcome overview of the study of sound, a field with diverse sub-disciplines, each with a broad range of real-world applications (see **Box 1**).

When people ask what I do and I reply that I'm an acoustic consultant, there are typically two responses: one is a genuine interest and curiosity, and the other is a somewhat bemused 'Oh really'?

But if I start talking to people about noise, about how there are really no 'acceptable' limits because everyone's perception of noise is different, about the types of noise that we experience, the sources of noise and how we use it, how it affects us, the psychological effects of noise, people suddenly shift from a position of bemusement to relating the topic to personal experience. It can be fascinating to watch the transformation – people are usually more interested in sound than even they realise.

My area of study is environmental acoustics, i.e. the sound that is all around us every day, and its effects on areas such as residential and industrial developments and occupational health, not, as most people immediately assume, performance acoustics (see **Box 1**) or nuisance (which is generally dealt with by local authority environmental health officers).


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BOX 1: ACOUSTIC SPECIALISMS

- **Environmental acoustics**: the ambient noise from traffic, industry and general daily activities that surrounds us every day, its effects on us and the wider environment;
- **Auditorium/performance acoustics**: the consideration of acoustics and acoustic design in any room intended for listening or recording in;
- **Medical acoustics**: the effects of noise on human health as well as the use of sound in medical diagnostics and treatment;
- **Ecological acoustics**: the effects of infrastructure and human activity on animals, i.e. construction and traffic noise on land, and noise from construction, military activities and geophysical surveying underwater (leading to whale strandings, etc);
- **Building acoustics**: the transfer of sound within buildings and between different uses within a building, i.e. commercial and residential;
- **Noise nuisance**: the adverse effects of neighbour noise;
- **Occupational acoustics**: the protection of workers from adverse noise; and
- **Vibro-acoustics**: the determination of noise arising from vibration.

HOW WE PERCEIVE SOUND

For many, our towns and cities are too noisy. So surely, the argument goes, if we reduced traffic volumes we would reduce noise. But if we took away half the traffic in our towns and cities, we would only reduce the noise by a barely discernible 3 decibels (dB). Because of the way that the human ear works, to halve the perceived loudness of traffic we would have to remove about 90 per cent of it – now there's a challenge!

However, the perceived loudness of a noise is not the only aspect of sound that human ears are capable of detecting. In addition to volume and pitch, humans are particularly sensitive to the *character* of noise itself. Tonal sound, such as a single, continuous drone, or an impulsive or percussive sound such as from pile-driving, is found to be more disturbing than an equally loud but non-tonal or 'steady' sound. So changes in the ambient noise situation or in the character of the sound can greatly affect how it is perceived, irrespective of whether the actual *level* of the noise changes.

Often, the perception of sound is not solely due to different patterns of air pressure waves reaching our ears. Trees and vegetation provide little-to-no effective screening from sound unless very densely planted and yet, whether or not a person can *see* a busy road affects the likelihood of disturbance and annoyance from noise. In a similar vein, the presence of excessive levels of dust from a construction site can result in a greater likelihood that residents nearby will also perceive a noise disturbance.

HOW NOISE AFFECTS US

An understanding of the adverse effect of noise is nothing new: the Greeks and Romans had specific civic ordinances designed to reduce annoyance due to noise.[1] The challenge for regulators and policy-makers is that we all perceive noise differently – people hearing the same sound will be affected differently depending on the context, their predisposition and any number of other subjective factors. It is perhaps the subjective nature of sound that causes it to so often be overlooked; while underpinned by fundamental physics, the personal experience of any sound can present us with an almost infinite range of opinions.

> **"to halve the perceived loudness of traffic we would have to remove about 90 per cent it – now there's a challenge!"**

People also habituate to sound over time, which can affect their perception. But an increasing body of research[2] suggests that long-term exposure to typically moderate noise levels, such as those that currently occur in many towns and cities, can lead to increased levels of stress and rises in blood pressure that sufferers may not be consciously aware of due to habituation. However, they can lead to increased incidence of cardiac illness and other adverse, secondary effects. And, as we've already seen, seemingly simple solutions, such as reducing the amount of traffic in urban areas, are likely to be largely ineffective.

HOW NOISE AFFECTS WILDLIFE

It is also important to note the negative impacts of anthropogenic noise on wildlife: in a very short space of time humans have introduced significant new and increased noises into the habitats of a wide range of species, noises that they have not evolved to deal with and that can have direct and devastating effects (see **Box 1**). Human infrastructure affects animals' ability to navigate, communicate and hunt. Examples include whales changing their migration routes, avoiding their normal feeding or breeding areas, and even stranding; disturbance to migratory birds feeding during the winter; the list goes on. The impacts of noise stretch further than the human ear and, like climate change, might we get to a situation where the damage caused to the global ecosystem by our noise intrusion passes a tipping point?

THE FUTURE?

Noise – or sound, to be more technically accurate – is clearly a complex and highly subjective subject. Its variability and subjectivity mean that it has, so far, been impossible for regulators and policy-makers to define strict levels of sound that are acceptable or permissible – the holy grail of environmental acoustics. Doing this, while recognising that current levels of urban noise are a significant, almost invisible, pollutant that is having undesirable effects on human and wildlife populations, is a multifaceted task that has led to a greater focus on addressing the perception of noise and its context. This, in turn, has produced a new field of research around soundscapes and the meaning and use of tranquillity as a method for reducing the adverse effects of noise. Technology, rather than simple, crude solutions, is likely to be of greatest help; electric vehicles, for example, can reduce noise very significantly without the need for drastic traffic-reduction measures.

The field of environmental acoustics is vast and, like so many environmental sciences, interdisciplinary. With ongoing developments in the role of sound in physical health and research establishing the importance of tranquillity for mental health, the regulation and policies governing 'safe' and 'acceptable' sounds are likely to come under further scrutiny. There's still a significant amount that we don't know about sound, about how animals use it and react to it, about the long-term health effects on humans and animals and, consequently, I would suggest that the future for research and development in the field of acoustics has never been stronger. ES

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REFERENCES

1. Goldsmith, M. *History of Noise*. ‹https://mikegoldsmith.weebly.com/history-of-noise.html› [accessed 28th October 2019]
2. Hahad, O. Kröller-Schön, S., Daiber, A. and Münzel, T. (2019) The Cardiovascular Effects of Noise. *Deutsches Ärzteblatt International*, 116 (14) pp.245–250. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6541745/

Protecting tranquillity

Graeme Willis explores the importance of tranquillity, particularly in the English countryside, and explains how it benefits people's health and well-being.

FEATURE

In common usage, many people associate tranquillity normally, though not exclusively, with the countryside. General surveys on why people visit the countryside reinforce this view. It is one of the main reasons people go there: for peace and quiet, 'to get away from it all' to somewhere that is 'unspoilt', to find a rural retreat.

Tranquillity is also enshrined in public policy as an aspect or quality of an area that is valued and worthy of protection, so in this context the meaning of the word needs to be clear. If policy circumscribes areas and what may happen to them in planning and development terms, then those who wish to develop, build on, alter what is there may be set against those who wish to protect an area. For this reason, policy should set out the parameters of what it seeks to protect to justify the restrictions it imposes. So what does tranquillity mean in policy terms and why does it matter?

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FEATURE

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POLICY ORIGINS

Mapping parts of Aylesbury Vale in Buckinghamshire for a transport study, Simon Rendell of ASH Consulting developed the idea of tranquillity as a way of valuing the undisturbed countryside as a natural resource in its own right. Campaign to Protect Rural England (CPRE), the countryside charity, and the Countryside Commission, adopted this idea and worked with Rendell in the early 1990s to develop maps of tranquil areas. These defined what was tranquil by the lack of infrastructure (roads, pylons, urban areas, airfields, railway lines, mines) and their attendant noise and visual intrusiveness. The quality of tranquil areas was defined by what was *not* there rather than being an expression of the presence of other qualities or special characteristics. These were of course implicit, understood, though not expressed in the early maps.

Mapping moved on: tranquillity itself subsequently came to be regarded as a distinctive characteristic in its own right. New national tranquillity maps of England created by Northumbria University were published by CPRE in 2006 and, slightly revised, in 2007. Researchers had consulted over 2,000 individuals to identify what contributed to, or detracted from, tranquillity and from this produced a model with negative factors (those that disturb tranquillity). As before, they also added positive factors – such as water, trees, birdsong, naturalness of land cover – that contribute to tranquillity. The model was combined with national datasets of these factors to generate a map with specific tranquillity scores for defined squares across all of England. Based on this research, CPRE went on to define tranquillity as 'the quality of calm experienced in places with mainly natural features, free from disturbance from man-made *(sic)* ones'.[1]

NATIONAL PROTECTION

Though the earlier maps of tranquil areas had led to some local policies on tranquillity, these maps in particular supported a CPRE campaign for new national planning policies to protect areas for their tranquillity. This was achieved when the government published the first National Planning Policy Framework (NPPF) in 2012, which included the power for local authorities to designate areas of tranquillity and smaller local green spaces for their especially tranquil qualities.

The introduction of tranquillity into national planning policy was a breakthrough, although its precise interpretation in planning terms still remains a developing area. Both the first and revised NPPF fail to give a formal definition of tranquillity or tranquil areas in their glossaries and the concept set out in the text is narrower than that developed through the Northumbria mapping research for CPRE. The main tranquillity policy appears in section 15, paragraph 180 (b), where it is limited to identifying and protecting 'tranquil areas which have remained relatively undisturbed by noise' and 'prized for their recreational and amenity value for this reason'.[2] As a result, intrusive visual features such as pylons, which are negative factors in the 2007 tranquillity maps, and landscape elements such as trees or rivers, which are positive factors, are not highlighted at all.

The national planning practice guidance that accompanies the NPPF also fails to provide a formal definition, but it does help interpret the policy further. It recognises that human sounds are the source of noise (unwanted sound) rather than natural sounds, such as waves at the coast, even though they can generate levels of sound energy that are similar to traffic. The planning practice guidance also recognises the human experience of such areas through the potential to enjoy 'a sense of peace and quiet' as well as 'a positive soundscape where natural sounds such as birdsong or flowing water are more prominent than background noise, e.g. from transport'.[3] Both of these are key aspects of tranquil areas in the countryside with low ambient noise that are captured in the CPRE tranquillity maps. Finally, the guidance also states that areas of tranquillity should be *relatively* free from noise so that such noise does not 'undermine the intrinsic character of the area'.[3] Further interpretation and professional judgment may be required to determine what that local character is and therefore set suitable noise thresholds, but the policy establishes that absolute low levels of (artificial) noise are not required for locations to qualify as areas of tranquillity. So, while the 2007 maps unsurprisingly rate rural areas as more tranquil than busier urban ones, there is real scope in the policy for urban, semi-urban or fringe areas to be protected for the relative respite and quiet they offer. Crucially, such areas are also likely to be locally accessible to a greater number of people and, as such, highly prized and frequented by their local communities.

Well in advance of any requirement from the European Noise Directive, the policy opened up the potential for councils to protect rural areas for their quiet. The inclusion of the capacity of such areas to 'provide a sense of peace and quiet or a positive soundscape'[3] is a valuable counter to so much of noise policy, which deals with sound in adverse terms. And the national planning practice guidance adds somewhat coyly that councils might consider how to enhance these areas 'through specific improvements in soundscape, landscape design (e.g. through the provision of green infrastructure) and/or access'.[3] The quality of landscape and, perhaps, the absence of major visual detractions or screening of them, may after all still be pertinent.

LACK OF CLARITY

The failure of national policy to define tranquillity and, as importantly, to set out how it might be properly assessed, means that in several ways there is unfinished business: for CPRE at least, the lack of a defined methodology,

FEATURE

nationally agreed and with government backing, means that citizens and their local authorities lack the tools to assess which areas might reasonably be defined by the new policy and, with a sound evidence base, be properly protected by it. The lack of definition merely adds to confusion and, though *enjoyment* of tranquillity is key to the policy, beyond peace and quiet there is no reference to the benefits to health and well-being of such places and spaces. In a time when we, as a society, are searching for solutions to mental health and obesity problems, this is surely an important opportunity missed.

Though it makes sense to start with an analysis of tranquillity mapping and policy as a key to why tranquillity matters, what is also clear is that the richness of the concept ultimately transcends both. Simon Rendell's original perception of the value of undisturbed countryside as a natural resource was as bold as it was breathtakingly simple. It stands the test of time. The maps of tranquil areas that Rendell then produced relied on a professional assessment of the impact of intrusive features across the landscape. The later Northumbria tranquillity research went beyond professional judgment to combine the views of thousands of participants into a consensus, an objective view, of what constitutes tranquillity by what adds or detracts from the experience of it, notably in rural settings. The policy it fostered relates to a professional view based fundamentally on an understanding of noise, though one informed by the role of natural soundscapes and the wider context, with, to a limited extent, the interplay of other qualities, including the visual.

MAKING MEASUREMENTS

If, in the end, the concept of tranquillity transcends maps, the metrics that underlie them and the policy, it may be that these are by their nature conservative. They attempt, of necessity, to pin down the real world in ways that are bounded and measurable to enable sound decision-making. Tranquillity is a hybrid in environmental terms, because it unavoidably embodies both objective and subjective elements: objectively determinable features in time and space (levels of sound, physical elements in the landscape that are natural and living or artificial) and the human perception of them, with the feelings that are engendered. This is a challenge but also, in some respects, an advantage.

It is worth comparing attempts to measure tranquillity with another highly influential and topical aspect of environmental policy. There is much debate about the best way to protect the natural environment and how its protection can be reconciled, integrated or, more usually, 'balanced' with economic growth. Much of the discussion has revolved around valuing the natural world in some way that is palpably more objective than subjective, more rational than emotional, more numerical than qualitative.

Debate around the protection of the natural world has increasingly focused on the benefits that humans derive from natural resources or, more technically, the ecosystem services they provide us with. Those natural resources are also assessed in terms of natural capital, from which the ecosystem services flow. The language of this kind of analysis is off-putting to some. In particular, it implies that, in the same way as financial capital, all nature can be counted and assigned an economic value, with the risk that it will be traded off against other economic values. It seems like a rejection of the appreciation of nature for its own sake, for its intrinsic value, subordinating nature to the needs of people. Nature is valued only for what it can do for us, as an instrument. In some way it seems to belittle the nature that often we stand in awe of.

Such concepts are valuable and important but require interpretation. They are essentially technocratic and require considerable knowledge to make sense of them and to make them work. As such they are doomed to be used in a limited policy world, without readily translating to the mass of people who do or should value the nature they seek to assess and protect.

THE IMPORTANCE OF SUBJECTIVITY

The primary purpose of CPRE's tranquillity mapping was to provide an objective assessment to support policy. The rigour of the work has enabled bodies such as Natural England, Highways England, national parks and other local authorities to use it.[4] But however objectively we seek to assess it, tranquillity retains an important subjective and personal component. Tranquillity is accessible to anyone who finds places and spaces largely free from noise and where the setting itself is rich in natural features: trees, plants, water, wildlife, natural sounds and smells. Tranquillity only requires a willingness to seek stillness away from life's hubbub and to engage with the natural environment; it is easily knowable and, in the countryside, easily and cheaply accessible. In this sense tranquillity is democratic, available to all.[5]

The feeling of tranquillity should be readily accessible to all in two senses. Research into green exercise has shown that people of all groups – irrespective of age, gender, social class or ethnicity – benefit from physical exercise in all types of natural environment.[6] This is part of a mounting body of evidence that shows that contact with nature is good for us, for our physical health and our mental well-being. This reinforces the case for all of us to have meaningful access to green spaces and contact with nature as part of our daily lives, perhaps as part of a right to nature. In the second sense, if all are able to benefit from being in nature – for its restorative qualities, especially for the stressed mind – it is hard not to conclude that the feeling of tranquillity in response to undisturbed nature is in some way hard-wired into the human brain.

So the tranquillity we experience in natural settings, I would argue, is an expression of an affinity with nature that is part of our evolutionary inheritance. We live and work in physical places, including digital and virtual worlds, controlled and organised by others, yet we retain the capacity to enjoy the calm that escape into natural environments can offer. Tranquillity matters, then, not only because of the real benefits such escape can provide as respite from the busyness of our day-to-day lives but also, more profoundly, as a reminder that we stand, despite the material and cultural trappings of our civilisation, in an intimate relationship with nature. It reminds us, if we will only take note, that we are of nature, dependent upon it in many obvious and subtle ways and as such, our fates are bound together. ES

Graeme Willis is a senior policy campaigner in the Rural Economy and Communities team at CPRE. He has worked on tranquillity since 2006, to advocate for policy change and the use of national tranquillity mapping data to underpin the protection and enhancement of tranquillity across the countryside. He has a master's in Environment, Science and Society from Essex University and did early fieldwork on the therapeutic benefits of woodland. Graeme has also taught at Anglia Ruskin University and the universities of Essex and Sunderland.

REFERENCES

1. CPRE. (2006) *Saving tranquil places: How to protect and promote a vital asset.* https://www.cpre.org.uk/resources/countryside/tranquil-places/item/1855-saving-tranquil-places [accessed 18th October 2019].
2. Ministry of Housing, Communities & Local Government (2019) *National Planning Policy Framework.* London: GOV.UK. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/810507/NPPF_Feb_2019_print_revised.pdf
3. Ministry of Housing, Communities & Local Government (2019) *Guidance: Noise.* London: GOV.UK. Paragraph: 008 Reference ID: 30-008-20190722. https://www.gov.uk/guidance/noise--2
4. See, for example, Natural England (2014) *National Character Area profiles: data for local decision making.* London: GOV.UK. https://www.gov.uk/government/publications/national-character-area-profiles-data-for-local-decision-making [accessed 18th October 2019].
5. This section takes a strong cue from text by Bronwen and Frances Perceval. My thanks to them for their inspirational writing.
6. Pretty, J., Rogerson , M. and Barton, J. (2017) Green Mind Theory: How Brain-Body-Behaviour Links into Natural and Social Environments for Healthy Habits. *International Journal of Environmental Research and Public Health,* 14 (7), p.706, doi: 10.3390/ijerph14070706.

CASE STUDY

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Acoustic deterrents as a bat-mitigation strategy

Nigel Burton explains the way that sound is used to increase bat safety around large infrastructure projects.

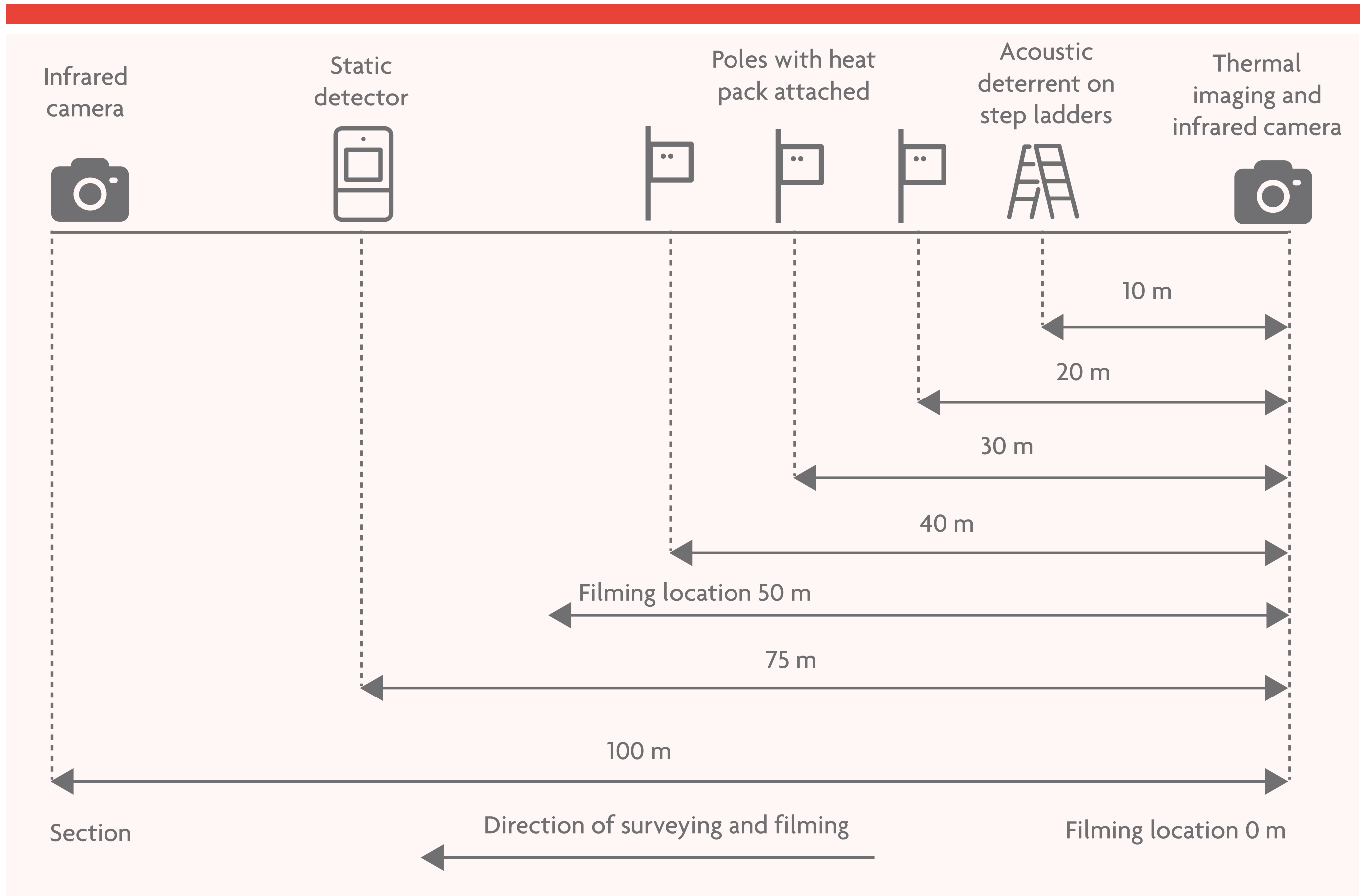
High Speed 2 (HS2) is a high-speed railway that is planned to run between London and Birmingham (Phase 1) and then from Birmingham to Manchester and Leeds (Phase 2). A section of the route planned for Phase 1 lies across well-used Bechstein's bat flightlines between fragmented ancient woodlands in North Buckinghamshire. This means that the railway could disrupt the movement of bats between roosts and foraging areas, with adverse effects on their conservation status.

Bats have sensitive and highly evolved acoustic apparatus and this, coupled with their complex habitat requirements and wide-ranging use of landscapes, means that they are vulnerable to disturbance, habitat fragmentation and death or injury caused by a wide range of development projects. Bechstein's bats (see **Figure 1**) are of particular importance as one of the UK's rarest and most endangered species, with some estimates that no more than 1,000 individuals exist in the whole of the UK. Added to which this specific population of 200–300 individuals is the most northerly in Europe and therefore of significant genetic value.

THE CHALLENGE

A variety of mitigation options were investigated to address the risk of bats colliding with trains as they fly the 800 m long western boundary of Sheephouse Wood, a site of special scientific interest (SSSI), which abuts HS2. The construction of a conventional tunnel or the use of lighting were rejected for logistical feasibility or safety reasons. The solution chosen was to provide an 800 m long mesh structure over the railway to direct bats to safely fly up and over the train line. However, there was the potential risk that bats would fly into either end of this structure and then be unable to avoid

▲ **Figure 1. A Bechstein's Bat. (© Adi Ciurea | Adobe Stock)**



▲ **Figure 2. Survey setup. (Adapted from an original diagram by © Charlotte Wevill, The Ecology Consultancy)**

oncoming trains. Therefore appropriate mitigation measures were required not only to achieve consent from Natural England, which required assurances that no bat mortalities would occur as a result of the scheme, but also to avoid the risk of costly and significant delays to the building of this section of HS2.

Acoustic output, in other words, the emission of ultrasonic sounds, is increasingly being used as a way of dissuading bats from sites such as churches and windfarms – the latter pose a risk of death and injury to bats. Instead of trying to exclude bats from a whole area, the project team determined that acoustic output could be used to deter bats from a particular area, thus allowing normal bat behaviour in the vicinity to remain the same. This finding could be a better approach to bat mitigation and be more widely used on infrastructure projects.

THE PROPOSED SOLUTION

Having identified potentially relevant work undertaken by the University of Bristol on the use of acoustic deterrents to relocate bats from churches, HS2 commissioned The Ecology Consultancy, BSG Ecology, the University of Bristol and Temple to work together to assess the potential for adapting existing technology for use on a high-speed rail project.

The initial objective was to determine the feasibility of using acoustic deterrents to eliminate the risk of bats entering the mitigation structure. A related issue was how to focus the deterrents so as to minimise noise spill to the surrounding sensitive habitats and the impact on public rights of way – some of these are located close to one of the proposed arrays of acoustic deterrents.

The project team needed to establish the following:

1. Were acoustic deterrents effective at deterring bats from a known flightline?
2. Over what distance and from which direction were acoustic deterrents effective?
3. What were the wider impacts of acoustic deterrents (for example on livestock, horses and pets) and did these vary under a range of environmental conditions?
4. What number and arrangement of acoustic deterrents would be required to provide effective mitigation to prevent bats from entering a mesh tunnel?

To answer questions 1 and 2, a four-week field study was undertaken in Radstone, Northamptonshire, which involved the operation of an array of acoustic deterrents at 20 minute intervals while monitoring bat behaviour using infrared and thermal-imaging cameras (see **Figure 2**).

To answer question 3, a literature review was undertaken to find the reported impacts of acoustic deterrents on livestock, humans and dogs. These were backed up with incidental findings from the field study.

To answer question 4, Temple measured the volume and directivity of the sound emitted by the acoustic deterrents. Due to the ultrasonic nature of the source, this was done using a bat detector and an FFT spectrum analyser with specialist microphone in the field (see **Figure 3**), and supplemented with further measurements off site. Calculations were used to determine the number of acoustic deterrents required to optimise the sound level at the tunnel entrances while minimising noise spill to the wider environment.

Work was also done to manage additional constraints of undesirable noise emission beyond the 'treated airspace' by focusing and funnelling the noise and providing sound barriers, based on the findings of modelling the sound emitted by the acoustic deterrents (see **Figure 4**).

The research study was carried out under licence from Natural England to satisfy their concerns that no bat mortalities would occur.

THE FINDINGS

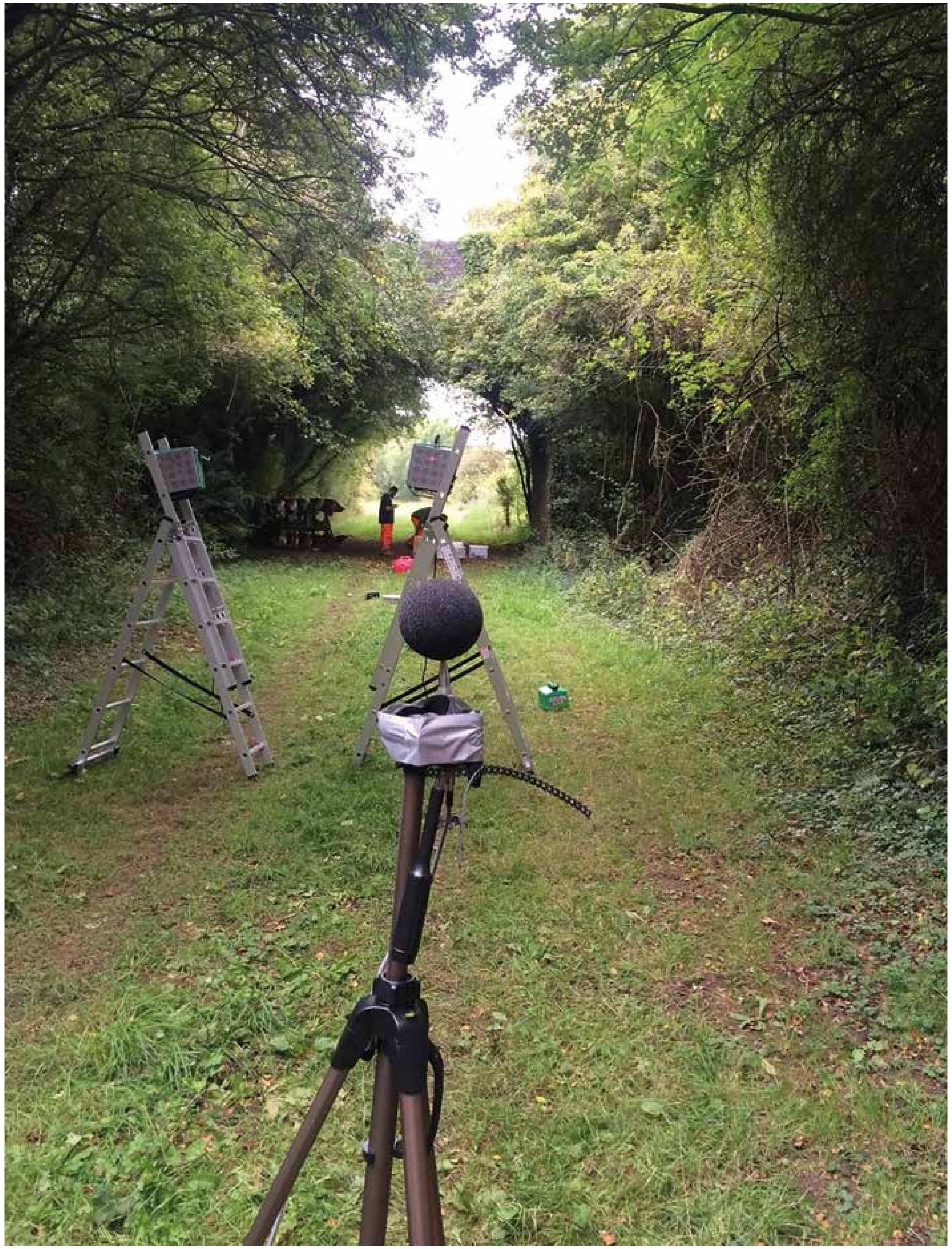
The following were the key findings of the research described above:

- Acoustic deterrents were highly effective at deterring bats, with a success rate of more than 98 per cent within 10 m of a unit (single acoustic deterrent);
- Testing established that the sound of the acoustic deterrents was generally emitted in a frontal conical shape, but that sound was also emitted behind the units;
- The distance of effectiveness of the acoustic deterrents on bat behaviour was found to be up to 20 m in front and 10 m behind the units; and
- Spillage could be successfully managed, funnelled and focused using a variety of techniques including barriers, angling of the units and sympathetic landscape and structural design.

Consequently, it was concluded that bats were deterred from entering the treated airspace and that there was a distance effect of the acoustic deterrents on bats.

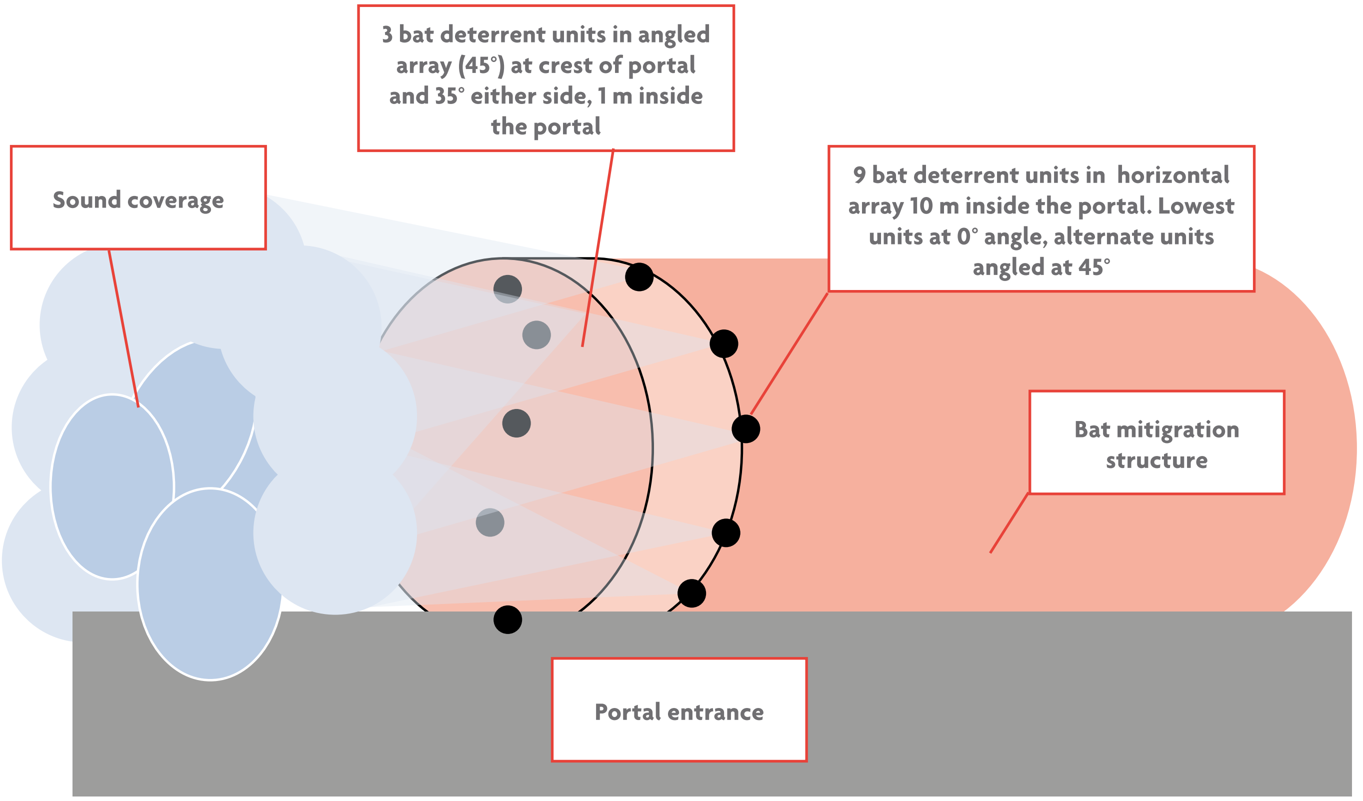
FURTHER WORK

The team hope to continue refining this work for application on projects with costly bat mitigation (either for temporary use during construction or for permanent use). This work will seek to provide existing and new



▲ **Figure 3. The field measurement setup. (© Temple Group)**

CASE STUDY



▲ **Figure 4. Mixed horizontal and vertical array of acoustic deterrents arranged to optimise coverage. (Adapted from an original diagram by © Temple Group)**

clients with cost-effective and robust solutions for bat mitigation where there is uncertainty around the effectiveness of existing methods used to maintain habitat connectivity for bats. In particular, we wish to establish whether deterrents could be used to divert bats to replacement flightlines and potentially increase adoption of new habitat prior to clearance of existing habitat. It will also seek to align with government policy promoting a bigger, better and more joined-up natural landscape.[1,2] ES

Acknowledgements Thanks to Jon Riley and Steph Murphy of The Ecology Consultancy with acoustic input from Dani Fiumicelli at Temple.

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REFERENCES

1. Lawton, J. (Chair) (2010) *Making Space for Nature: A review of England's Wildlife Sites and Ecological Network.* London: Defra.
2. Secretary of State for Environment, Food and Rural Affairs (2011) *The Natural Choice: securing the value of nature.* Norwich: TSO. (CM 8082)

What is an appropriate soundscape?

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ANALYSIS

Richard Cope and **Yiying Hao** give an overview of why our soundscapes matter and how they can be improved.

Within acoustics, researchers are interested in evaluating the quality of acoustic environments from the perspective of human perception (e.g. pleasantness, naturalness and annoyance). It is believed that a healthy acoustic environment is more than simply the absence of unwanted sound. The term 'soundscape' refers to the acoustic environment as perceived, experienced or understood by people in any given context, and this includes beneficial and neutral sounds as well as noise. It has a broader focus than just clamping down on the decibels, recognising that we also need to create appropriate soundscapes – the right acoustic environment at the right time and in the right place.

Soundscape approaches start from human perception and understanding users' needs and expectations of a space. There is an increasing body of evidence demonstrating that high-quality soundscapes can promote health and well-being as well as encouraging the use of those spaces. So towns and cities should contain a variety of soundscapes appropriate to the land use. Soundscape ecology is also employed in studies on biodiversity, ornithology and ecological well-being assessment, and encourages the preservation of diverse natural sounds for habitats. The fruitful research outcomes contribute to the landscape and urban design/planning guidance, noise management, transport design, cultural heritage protection and so on.

SOUNDSCAPE PRINCIPLES

Soundscape design practice is still in its infancy, although a lot of principles have been demonstrated by research.[1,2]

CONSIDERATION OF CONTEXT

The definition of soundscape given by the International Organization for Standardization (ISO) identifies the importance of context in the measurement and evaluation of the acoustic environment. The context is the physical space where the acoustic environment exists, and it:

...includes the interrelationships between person and activity and place, in space and time […] and may influence soundscape through (1) the auditory sensation, (2) the interpretation of auditory sensation, and (3) the responses to the acoustic environment.[3]

▲ **Figure 1. An aerial view of Buitenschot Land Art Park/. (©Your captain luchtfotografie)**

Increasingly, research evidence indicates that sound levels are not a sufficient or straightforward marker against which to judge the results of the acoustic environment assessment. Sound preference, meaning of sound sources, user expectation, masking effects between unwanted sounds and wanted sounds, and visual context significantly influence human responses to the acoustic environment.

Users of spaces prevent themselves from being annoyed and adapt their expectation when they are familiar with the composition, pattern and changes of the soundscape. Individuals' sound comfort is moderated by their perception (both conscious and subconscious) and their psychological and physiological responses. In general terms, these responses are managed through intention, attention, immediate action and proaction. These interdependencies make soundscape management more complex than traditional noise-control methods.

ADDING OR ENHANCING POSITIVE SOUNDS

Soundscape approaches recognise sound as an environmental resource. It is essential to consider sounds in a positive way, which creates more opportunities to improve our acoustic environment with multiple sound sources. Positive soundscapes and urban greenery design are more sustainable: ecological solutions with a focus on the value of urban environment improvement can attract residents, businesses and workers instead of purely reducing noise levels.

Currently, the main principles of soundscape management and design are mainly to enhance wanted sounds and reduce unwanted sounds. Sound masking, which is one of the most significant daily-life hearing phenomena[4] and has considerable effects on the quality of soundscape, is considered to be the most powerful tool to achieve this.[5,6] Masking means making sounds inaudible or partially inaudible with other sound(s): enhancing or superimposing specific or interesting sounds, naturally or artificially, to mask the undesirable sounds. (The concept of masking is frequently explained and explored in psychoacoustics). Masking effects may not reduce perceived loudness directly, but they can significantly reduce annoyance and improve the naturalness and pleasantness of noise.[7] The evidence of the masking effects from soundscape and psychoacoustics can be used in both soundscape assessment and design. Careful demonstration and assessment of masking effects are needed in a soundscape design to avoid worsening the existing soundscape.

LANDSCAPE DESIGN

Soundscape and landscape are highly connected. Sound sources associated with diverse landscape elements (geophony) exist in urban and rural green spaces, whilst vegetation in green spaces provides habitats for sound-producing organisms (biophony). Vegetation absorbs sound as well as producing it – an example is wind blowing through leaves.

People have different sound preferences in different spaces, but in general, natural sounds are highly ranked.[8] Among the natural sounds, sounds from water and foliage, which are commonly used landscape design elements, are believed to be the most desirable.

Landscape also influences the soundscape in term of aural–visual interaction. By means of perceptual experiments, a natural view has been demonstrated to increase the pleasantness and naturalness of soundscapes, and decrease annoyance in human perception.[7,9] The phenomenon can be considered to be a form of masking by attention diversion.

Noise mitigation can be also achieved by landscape design, which is more sustainable and cost-effective than traditional noise control, which focuses on noise level abatement by sound source enclosure or noise barriers, particularly for the area exposed to the inevitable noise. Buitenschot Land Art Park, to the southwest of Amsterdam's Schiphol Airport, is a good example of noise mitigation by large-scale landscaping (**Figure 1**). The landscaping reduces noise sustainably by dispersing airport ground noise using a set of 3 m high embankments that face in different directions. As a piece of land art with walking paths for local visitors, it also adds aesthetic and recreational value to the area. It is believed that the innovative collaboration between the landscape and soundscape design is promising for global environment improvement and sustainable development, especially for large infrastructure projects.

SOUNDSCAPE PRACTICE

Ideally, soundscape design begins with the determination of users' perception of the outdoor sound environment,[10] via questionnaires, surveys and interviews, followed by sound measurement and analysis, which is used for soundscape mapping. The final stage (design and optimisation) leads to practical integrated measures, including noise control, design with masking, and social surveys of stakeholders' feedback on the soundscape

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design. However, given often-limited project times and budgets, previous research outcomes and good practice can be properly considered and referred to in the soundscape design instead.

The design options available need further development through collaboration and innovative thinking so that a greater variety of solutions can be implemented. Soundscape design and management take into account the interests of different groups, e.g. stakeholders, transport authorities and developers. Harmonious solutions can be defined with the help of urban technicians to create a desirable urban soundscapes. For example, ecological consultants can recommend measures to protect and enhance bird habitats, but that process does not currently consider what effect a particular species may have on the soundscape to be enjoyed by people. It is useful therefore to consider measures to encourage particular bird species that are valued for their song to an area.

Once more, attention is paid to soundscape practice and professionals are more familiar with soundscape principles and approaches, soundscape assessment and design can be applied in a wider range of projects. In urban spaces, soundscape design can be used to design waterscapes, develop and improve public spaces, and add sound-related architectural installations to make the urban sound environment more pleasant, safer, richer, more natural and more vital. Regarding the cultural heritage, soundscape assessment and design can be used in the regeneration and preservation of urban areas that include cultural heritage/soundmarks and intangible cultural heritage. Natural sound enhancement and biodiversity increase can also be incorporated into soundscape design, and associated ornithology and ecology can provide sound signal evidence. Finally, there have been good-practice examples showing the important roles of soundscape in urban transport structure design or redesign alongside tranquillity assessment and protection, which are promising for transport projects in the future. **ES**

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◄ **Photos © Yiying Hao**

REFERENCES

1. Kang, J. (2006) *Urban Sound Environment.* London: CRC Press.
2. Kang, J. and Schulte-Fortkamp, B. (eds) (2015) *Soundscape and the Built Environment.* Boca Raton: CRC Press.
3. ISO (2014) ISO 12913-1:2014 Acoustics -- Soundscape -- Part 1: Definition and conceptual framework
4. Zwicker, E. and Fastl, H. (1999) *Psychoacoustics – Facts and Models* (2nd edn). New York: Springer.
5. Hellström, B. (2009) Acoustic design artefacts and methods for urban soundscapes. 16th International Congress on Sound and Vibration. Krakow, Poland, 5–9 July.
6. Bouzebari, M., Bento Coelho, J.L., Carvalho, T.M. and Alarcão, D. (2009) The soundscape project as an alternative solution for urban noisy places: the case of Alcântara Bridge in Lisbon. 8th European Conference on Noise Control. Edinburgh, UK, 26–28 October.
7. Hao, Y., Kang, J. and Wörtche, H. (2016) Assessment of the masking effects of birdsong on the road traffic noise environment. *Journal of the Acoustical Society of America*, 140, p.978.
8. Yu, L. and Kang, J. (2010) Factors influencing the sound preference in urban open spaces. *Applied Acoustics*, 71 (7), pp.622–633.
9. Jeon, J.Y., Lee, P.J., Hong, J.Y. and Cabrera, D. (2011) Non-auditory factors affecting urban soundscape evaluation. *Journal of the Acoustical Society of America*, 130 (6), pp.3761–3770.
10. Bento Coelho, J.L. (2015) Approaches to urban soundscape management, planning, and design, in Kang, J. and Schulte-Fortkamp, B. (eds) *Soundscape and the Built Environment.* Boca Raton: CRC Press.

FEATURE

How do you measure tranquillity?

Clive Bentley describes a new, systematic approach to assessing our quiet outdoor spaces.

Acousticians have been predicting and assessing the detrimental impacts of environmental noise on people and the places where we live and work for many years. To date, most research on environmental noise has focused on its adverse impacts on human health and well-being. Standards and guidance for development and planning offer directives for assessment and mitigation.

However, not all environmental sound is detrimental. Consideration of the positive effects of sound is a more recent development. As the science (or art, for some) of soundscapes becomes more common, so too comes the recognition that some environmental sounds are not noises to be mitigated but are in fact desirable.

One of these desirable soundscapes is tranquillity – found in outdoor places that feel peaceful and quiet. Whilst tranquillity is, to an extent, subjective, new research indicates there are measurable acoustic consistencies in tranquil settings that are experienced in a similar way by a range of different individuals.[1] That research has underpinned the development of a new assessment method that allows tranquillity to be measured and assessed. This, in turn, provides an accurate evidence base for decision-making around planning, development and design. The technique has a range of applications for outdoor areas, including Areas of Outstanding Natural Beauty, national parks and heritage properties, public parks and mixed-use leisure destinations. Most recently it has been used as part of submissions on noise and vibration at hearings regarding the planned A303 Stonehenge Expressway (see **Figure 1**).

▲ **Figure 1. Stonehenge: English Heritage and the Highways Agency claim that the new tunnel scheme would improve tranquillity. However, tranquillity at Stonehenge is dominated by visitors (and their audio guides), so removing the road would have a negligible effect. (© Clive Bentley 2019)**

WHY IS TRANQUILLITY IMPORTANT?

Many studies have demonstrated the considerable health benefits of being in a natural, tranquil place. The primary value is the promotion of mental serenity – a state not so easily found in our always-connected modern lives. Rest, relaxation and revitalisation are also found in tranquil places. Unsurprisingly, tranquillity is more often found in natural settings rather than built environments. Tranquil outdoor spaces can be particularly beneficial for those with mental-health problems, with multiple studies showing positive outcomes for those experiencing depression and anxiety. The reason why people find these natural environments helpful is that they provide what psychologists refer to as 'effortless attention' or 'soft fascination'.

When imagining a tranquil place, one will likely think of a rural or wild location – but tranquil havens, such as sheltered gardens, communal terraces and squares are also important in urban environments. Increased nature in these urban environments will further improve the tranquillity of these areas[2] and provide positive health and well-being outcomes for nearby residents and workers.

WHAT MAKES A PLACE FEEL TRANQUIL?

In its purest form, tranquillity is a state of mind rather than a specific feature of a place, so it can be affected by many factors. Historically, it was often referred to as a feature of landscape and appeared only within landscape and visual assessments. In fact there is a wide range of factors which affect the tranquillity found in a particular place (see **Box 1**).

BOX 1: THE ELEMENTS THAT CONTRIBUTE TO A LOCATION'S TRANQUILLITY

Environmental factors:
- Sound – levels and types of sound
- Visual appearance – landscape
- The character of the area around the site of interest – the neighbourhood tranquillity
- Presence of water (rivers, lakes, waterfalls, fountains, sea)
- Perceived safety (e.g. other people, biting insects, presence of birdsong)
- Comfort (e.g. somewhere to rest, weather conditions)
- Smells
- Textures

Personal factors:
- Current psychological and/or emotional state
- Past experience of a site
- Feelings/expectations about a site

The presence and behaviour of other people is an interesting factor. While many may consider that tranquillity is best experienced alone, some studies show that many people prefer there to be others around them in order to feel safe. The influence of others may have more to do with what they are doing rather than simply their presence in a location.

Birdsong appears to be particularly important. Not only is it generally considered to be a pleasant sound (and something which clearly provides 'soft fascination'), it has been suggested that the presence of birds is a subconscious indicator that the location is safe. In other words, if a predator were nearby, the birds would fly away.

The character of the area around the site of interest has a strong influence. A green space in a city may be subject to quite high noise levels and a reasonable amount of distracting activity, but if it is noticeably nicer than the surrounding area, it is likely to be considered to be quite tranquil by those who use it. The same space in a rural location would, of course, not engender the same response.

Figure 2 below shows How Hill in the Norfolk Broads on a fairly busy day. The movements of the pleasure boats and activities of visitors reduce tranquillity but the natural sounds are also very significant – the location is known for its tranquillity.

▲ **Figure 2. Tranquillity mapping (see Table 1) for How Hill in the Norfolk Broads Maps. (©Clive Bentley 2019)**

People's feelings about or attachment to a place are also very important. People will often ignore factors which detract from a favourite place and generally tend to feel that 'their' place is more special than other places, even if a neutral observer would not agree.

There are many different factors which can influence perceptions of tranquillity, but it has been found that sound level and character is most important in determining how tranquil somewhere feels.

EXISTING POLICY AND GUIDANCE

The UK government's Planning Policy requires that those drafting planning decisions (and local policies) '…identify and protect tranquil areas which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason'.[3] Additional guidance in the UK government's National Planning Practice Guidance suggests that:

"For an area to justify being protected for its tranquillity, it is likely to be relatively undisturbed by noise from human sources that undermine the intrinsic character of the area. It may, for example, provide a sense of peace and quiet or a positive soundscape where natural sounds such as birdsong or flowing water are more prominent than background noise, e.g., from transport."[4]

There are well-established drivers to promote, improve and protect tranquil places. However, without a reliable way of assessing tranquillity or an agreed definition of what it means, the designation of tranquil and quiet areas and their subsequent protection has been difficult to achieve. This also means the degree of protection afforded is likely to be inconsistent. For this reason alone, a reliable, repeatable method of assessment has been needed.

Work by the Campaign to Protect Rural England (CPRE) and others has produced a range of new approaches to try to assess how tranquil a location is. However, none to date has taken proper account of the beneficial effects of natural sound or the presence of people. There are also other limitations and unreliable assumptions factored into each approach. So while these approaches have been important in the development of science, they are not able to be used to reliably inform planning policy and decisions or to design mitigation and enhancement schemes. This has continued to prevent adherence to planning guidance regarding tranquillity and more importantly, accurate identification and measurement of tranquil outdoor spaces worth protecting.

ASSESSING TRANQUILLITY OUTDOORS

In conjunction with the acoustic consultancy, Sharps Redmore, I have developed a new method to assess tranquillity outdoors that addresses the shortcomings of existing assessment approaches and meets the requirements of planning guidance. The Natural Tranquillity Method is based on field surveys of a range of parameters and subjective tranquillity scores given by surveyors visiting 1,600 sites over the last four years. From analysis of the level and character of sounds present, the method provides a reliable, objective assessment of how tranquil a place is. Noise from different modes of transport (appropriately weighted), other human-made sounds, natural sounds and the overall sound level (also weighted, where needed) are combined to give the tranquillity score shown in **Table 1.**

▼ **Table 1: The Natural Tranquillity Method scoring system**

Tranquillity score*	Description
1	Chaotic/frantic/harsh
2	Busy/noisy
3	Slightly busy/unsettled
4	Not quite tranquil
5	Just tranquil
6	Fairly tranquil
7	Good tranquillity
8	Excellent tranquillity
9	Perfect tranquillity

***These scores can then be used to produce maps of an area to provide a tranquillity baseline against which proposed changes can be assessed.**

▲ **Figure 3. Tranquility mapping (see Table 1) for Phoenix Gardens in central London. (© Clive Bentley 2019)**

Phoenix Gardens (see **Figure 3**), in the heart of London's West End, is considered by many to be an oasis of tranquillity. In fact, it does not score particularly highly but is so much better than the surrounding area that it clearly has value.

TRANQUILLITY – THE LONG VIEW

The positive benefits for health and well-being provided by our tranquil spaces outdoors are well documented. In cities, even places which are not so quiet can be important if they are more tranquil than other areas nearby. In the countryside, areas which are particularly tranquil are becoming less so as development spreads into greener spaces. It is therefore important to protect and enhance these tranquil spaces for the benefit of people now and in future generations. Once these places are lost, it is rarely the case that they are reinstated. ES

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Watch Clive's webinar: http://bit.ly/2JySR7q

REFERENCES

1. Bentley, C. (2019) *Tranquil Spaces.* Copdock: Sharps Redmore Press.
2. WHO (2016) *Urban green spaces and health – A review of evidence.* Copenhagen: World Health Organization Regional Office for Europe.
3. Ministry of Housing, Communities and Local Government (2019) *National Planning Policy Framework (NPPF),* paragraph 180. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/810507/NPPF_Feb_2019_print_revised.pdf
4. Ministry of Housing, Communities & Local Government (2019) *Guidance: Noise.* London: GOV.UK. Paragraph: 008 Reference ID: 30-008-20190722. https://www.gov.uk/guidance/noise--2

Green: The Summer Photography Competition

Announcing the winner and runners-up to showcase the best shots that you sent in.

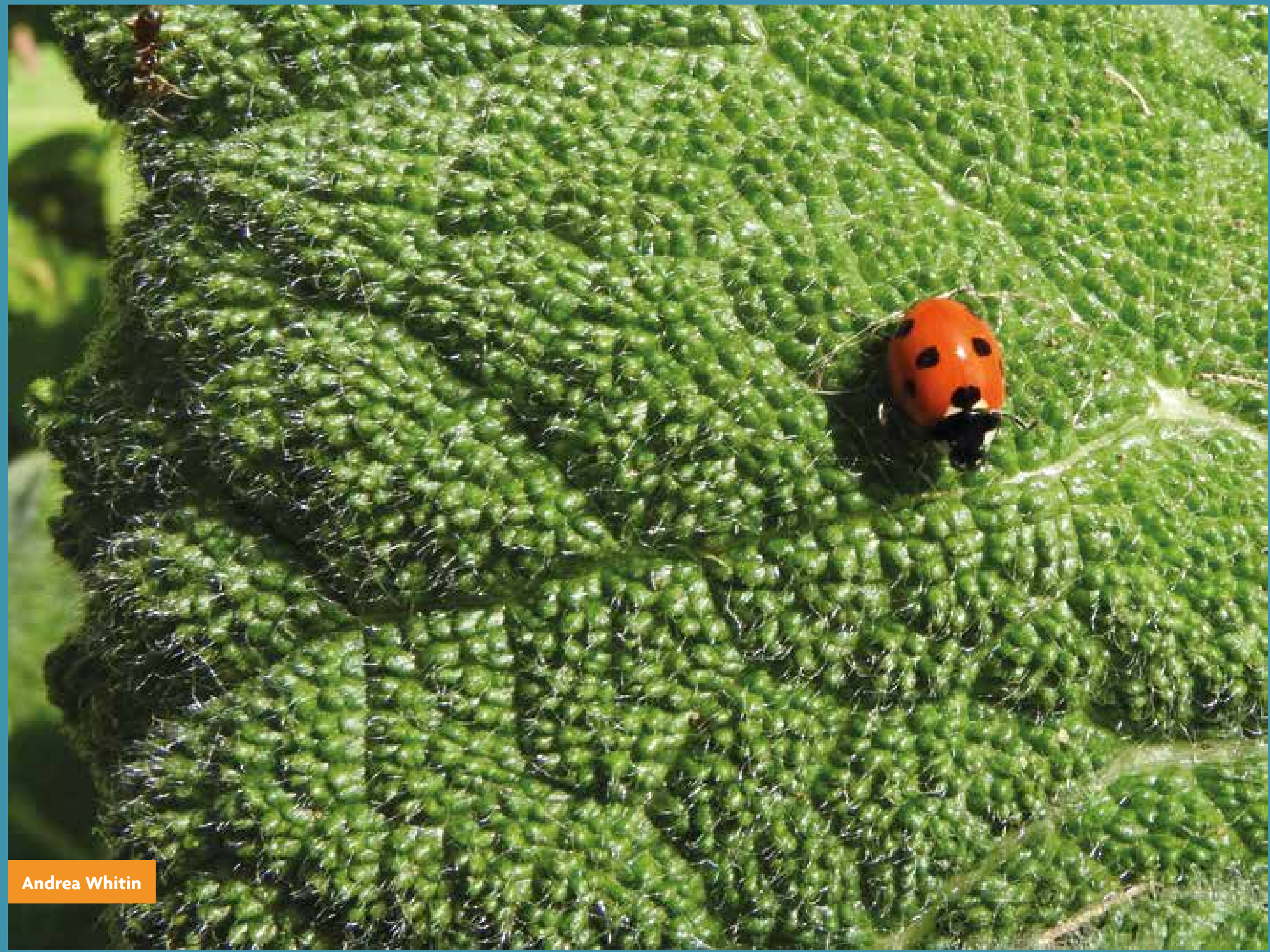
In response to our call for photographs on the theme of Green, we received over 100 entries, all of an incredibly high standard. From these, the judges shortlisted 26 images. The judges then asked to rank their top five images from first, worth five points, to fifth, worth one point.

The winner, with a final score of 31 points (more than double the points of any other entry) was Roger Barrowcliffe's image of a common frog emerging from a duckweed-covered pond.

Winner

Roger Barrowcliffe

Hilary Snelling



Andrea Whitin


Hanan Jafar


Kyle Johns


Lisa Abbott

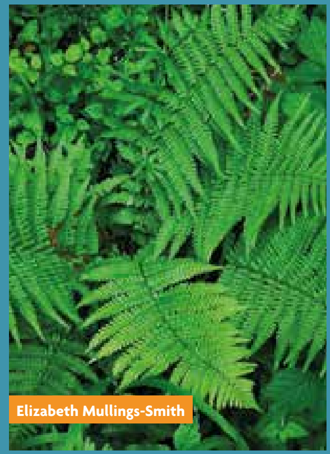

Jessica Brislin Higgs


Paddy Fowler


Chris Long


Kyle Johns


Issie Miles


Elizabeth Mullings-Smith


Jimi Irwin


Caroline Hardie


Michael Brown

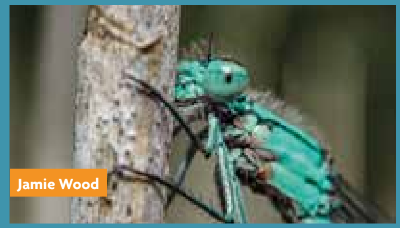

Anil Kolapkar


Tim Townsend


Daria Prihradska


Charlotte Bragg

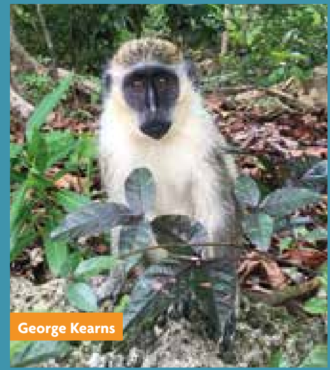

Cyrielle Delvenne


Jamie Wood


Noel John


David James


Joanne McKenzie


George Kearns


Natalia Ciarra


Urwal Bhagwat

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Matthew Shore – Geo-Environmental Engineer
Drew Smith – Graduate Environmental Advisor
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Madeleine Weight – Graduate Environmental Engineer
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Constructing relationships with noise

ANALYSIS

Colin O'Connor looks at how construction noise is measured, managed and addressed with local residents.

Realistically, anyone who has to live, play, study or work next to a construction site is going to be affected by noise emissions. Over the last decade I have worked on a number of large construction projects and interacted with local authorities and residents' groups to make sure their interests are taken into consideration – from the early stages of planning right through to completion. Below I look at issues around the metrics used to measure noise and the reliance on set limits; the importance of community engagement; and the current trend of making data publicly available.

WHERE DO THE NUMBERS COME FROM?

In the UK, British Standard 5228[1] provides standardised methods for assessing construction noise, together with prescriptive guidance on the magnitude of impacts and the likelihood of significant effects. These can be applied to various periods during weekdays and weekends in the context of existing levels of pre-construction ambient noise. BS5228 metrics can be traced back to the Wilson Committee report on noise[2] and subsequently Advisory

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Leaflet 72,[3] which recommended two fixed limits for construction noise: one for 'rural, suburban and urban areas away from main road traffic and industrial noise' and the other for 'urban areas near main roads in heavy industrial areas'. These values were selected on the basis of interference with conversation in occupied buildings, and provide a starting point for quantitative assessments.

Although the human response to noise varies widely and depends on the surrounding context, there is little direct research on the overall health effects of construction noise on communities. BS5228 does not present any research into the subject but does advise that the effects of construction noise include 'interference with speech communication, disturbance of work or leisure activities, disturbance of sleep, annoyance and possible effects on mental and physical health'. World Health Organization (WHO) guideline studies[4,5,6,7] of transport, wind turbine and leisure noise provide scientific evidence that noise exposure can induce hearing impairment, hypertension, ischemic heart disease, annoyance, sleep disturbance and decreased school performance. However, these are not related back to effects of construction noise. Similarly, research into occupational noise and hearing damage is readily available but is not comparable to noise from construction. The Control of Pollution Act 1974[8] provides legal mechanisms for managing construction noise and vibration on worksites but, as a legislative document, does not prescribe guidance on noise effects from construction.

This is not just a UK issue. Other countries also set limits for construction noise,[9] but the fact that the selected limits vary enormously from one country to another suggests that societal norms differ on how construction noise is viewed.

REDEFINING NOISE

We often define noise as 'unwanted sound', but how about expanding that definition to include '*unexpected* sound'? A lot of the concern about construction noise is triggered by not knowing what is happening. Common questions I have been asked by local residents include 'What times will noisy works take place?' 'Will my child be able to do their homework in the evening?' 'Is it during my baby's nap time?'

There is a tendency to undertake technical assessments of construction noise that define whether predicted levels are above or below a set threshold. Where the predicted level is below the threshold for construction noise, it is often deemed to be acceptable and no further mitigative actions are taken. Consultants, engineers and other technical types love working with numbers. Why wouldn't we? We need a target to give us direction in our work, and there is pleasure in coming up with a solution that agrees with the criteria. But does any of this matter to the people who have to experience construction noise? It is easy to focus on the numerical analysis and lose sight of why these assessments are being done in the first place.

It is often more important to tell those affected in advance when the work will take place, explain why the development is needed, indicate the scale of the noise and when they will experience these effects, and communicate what measures are being implemented to minimise noise. All of this needs to be supported with appropriate communication channels, such as letter drops, noticeboards or websites, regular community-liaison working groups and well-advertised hotlines for any questions or concerns. No technical acoustics terminology is needed whatsoever.

"It is easy to focus on the numerical analysis and lose sight of why these assessments are being done in the first place."

Through consultation and engagement, we can address people's particular concerns and come up with solutions that are acceptable to them. By working together with us in this way, they become directly involved and also feel ownership of the process, which helps to remove the unexpected element from unwanted sound. Of course, the unwanted element remains. However, understanding and engaging with the long-term benefits of a construction project can far outweigh concern about short-lived noise.

TOO MUCH DATA?

Technological innovations mean that we now have the monitoring capabilities to capture noise and vibration data, host live data on easy-to-access websites and pre-emptively send out alerts well in advance of any agreed limits being breached. Society today is hungry for as much data as possible, but there are technical constraints on providing live construction-noise data to third parties:

- Noise monitoring is primarily a management tool to warn contractors of potential exceedances so that they can take steps to avoid any breaches.
- Weekly and monthly monitoring reports are often prepared by contractors to demonstrate Section 61 (of the Control of Pollution Act 1974) consent compliance to the local authority. The raw data is verified, validated and authorised before it is formally reported, so giving raw data to third parties would undermine this process.
- Raw data can be misinterpreted because it has not been stripped of non-construction noise – for example: high winds, rainfall, physical disturbances or events such as a helicopter flying past.
- Providing large amounts of live raw data will inevitably lead to many more queries. This would mean contractors and local authorities having to commit extensive resources to responding to these questions, potentially diverting their efforts away from actually reducing and managing the noise itself.

While there are wide-ranging benefits to being transparent with local stakeholders, direct sharing of live noise-monitoring data can clearly have unforeseen consequences. It is crucial that on-site mitigation measures are given priority because it is those, rather than the monitoring, that avoid or reduce noise.

RELEVANT COMMUNICATION

We live in an age where there is so much data and information available that it is easy to be overwhelmed. As more specialists become available who can make sense of data, we need to make sure that its meaning is communicated to those on the receiving end in a way they can easily understand. Purely focusing on technical measures can sometimes ignore the real problems of day-to-day life. As specialists in our individual disciplines we need to communicate compassionately and empathetically in order to establish common ground. **ES**

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REFERENCES

1. British Standards Institute (2014) BS 5228:2009+A1:2014 – *Code of practice for noise and vibration control on construction and open sites.* Noise, London: BSI Group.
2. Committee on the problem of noise – Final report (1963) Command paper 2056. London: HMSO.
3. Department of the Environment (1976) *Noise control on building sites.* Advisory Leaflet 72 (3rd edn). London: HMSO.
4. Berglund, B., Lindvall, T. and Schwela, D.H. (1999) *Guidelines for Community Noise.* Geneva: World Health Organization.
5. World Health Organization (2009) *Night Noise Guidelines for Europe.* Geneva: World Health Organization.
6. WHO European Centre for Environment and Health, Bonn Office (2011) *Burden of disease from environmental noise: Quantification of healthy life years lost in Europe.* Copenhagen: WHO Regional Office for Europe.
7. World Health Organization Regional Office for Europe (2018) *Environmental Noise Guidelines for the European Region. Copenhagen:* WHO Regional Office for Europe.
8. United Kingdom. Control of Pollution Act 1974. London: HMSO.
9. Granneman, J.H. (2013) Construction noise: overview of regulation of different countries. *Internoise: Noise Control for Quality of Life.* Innsbruck, Austria, 15–18 September 2013.

ANALYSIS

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Planes, trains and automobiles: Noisy city management

David Trew gives an overview of urban noise, its effects and current efforts to control it.

Sound is a by-product of human activity. Everything we do generates sound. While at work in a busy office we spend our time talking to colleagues and clients either in person or on the phone. This helps in performing tasks but can have adverse effects on nearby colleagues: distraction, annoyance or lack of privacy. Other sounds in the workplace may be more substantial, such as those in a large factory. These run alongside the economic success of a business, but present a risk of hearing loss to staff if not correctly managed. However, it is transport and commercial noise that can dominate the sound environment at home, at work and at play for many people.

Any unwanted sound is defined as noise. As traffic and commercial sound is rarely wanted, it is called environmental noise, and it can have a serious impact on health and well-being. Recent World Health Organization (WHO) guidelines[1] have quantified that at least 100 million people in the European Union (EU) are affected by road-traffic noise. It is also estimated that at least 1.6 million healthy years of life are lost annually due to traffic noise. Surely, we cannot continue in this way.

▼ **Table 1. An extract from WHO's Guidelines for Community Noise (CNG)**

Specific environment	Critical health effect(s)	Noise metric		
		dB L_{Aeq}*	Time base** [hours]	dB L_{Amax}***
Outdoor living areas	Serious annoyance, daytime and evening	55	16	–
Outdoor living areas	Moderate annoyance, daytime and evening	50	16	–
Outside bedrooms	Sleep disturbance, window open (outdoor values)	45	8	60
Dwellings, inside bedrooms	Sleep disturbance	30	8	45
Dwellings, indoors	Speech intelligibility and moderate annoyance, daytime and evening	35	16	–
School classrooms and pre-schools, indoors	Speech intelligibility, disturbance of information extraction, message communication	35	During class	–

*** and *** Sound levels in the environment vary significantly during the day. The 1999 WHO guidelines are presented in terms of two different noise metrics: dB LAeq (which in simple terms can be considered to be the average level over the 16 hours from 07:00 to 23:00) and dB LAmax (which represents the noise maxima, usually called max levels, and is used to assess sound from individual events, typically passing trains or aircraft at night. These are usually associated with potential night-time sleep disturbance effects).**
**** The 16-hour (daytime) time base starts at 07:00 and ends at 23:00; the 8-hour (night-time) time base starts at 23:00 and ends at 07:00.**

NOISE MANAGEMENT

The first recorded formal controls of noise were in Ancient Greece: in the 6th century BC, the city of Sybaris banished noisy trades outside the city walls to ensure that the citizens could sleep undisturbed. Even cockerels had to be kept outside the city.

Currently, the management of noise is driven by regulation, policy, economics and scientific research into the adverse effects of noise on the population. In 1999, WHO produced *Guidelines for Community Noise* (CNG),[2] which included guideline values associated with the onset of what they called 'critical health effects' (see **Table 1**).

REAL-WORLD MEASUREMENTS

In 2000, the Building Research Establishment (BRE) carried out a government-funded measurement exercise to quantify the exposure of the population in England and Wales to external sound.[3] The survey included noise measurements outside 1,160 dwellings spread across rural, suburban and urban locations. The results in terms of the noise metrics used in the 1999 CNG are reproduced in **Table 2.**

Based on the England and Wales survey data and the WHO guidelines, the BRE survey paints a bleak picture of the UK, suggesting that most of the UK is moderately annoyed in their outdoor living areas and two-thirds of the population is at risk of sleep disturbance (with their windows open). Are England and Wales full of annoyed and sleep-deprived people? They may very well be but are those people annoyed by noise? The 2000 measurement study was supplemented with social research presented in the *Noise Attitude Survey*.[4] This presented a much less bleak outlook.

▼ **Table 2: Extract from the *National Noise Incidence Survey*[3]**
*** Note on units: see notes under Table 1.**

Specific environment	WHO 1999 CNG onset of critical health effect(s)	Percentage exposed above this level in the UK
Outdoor living areas	Serious annoyance, daytime and evening, 55 dB $L_{Aeq,16h}$*	54
Outdoor living areas	Moderate annoyance, daytime and evening, 50 dB $L_{Aeq,16h}$*	90
Outside bedrooms	Sleep disturbance, window open (outdoor values), 45 dB $L_{Aeq,8h}$*	67
Outside bedrooms	Sleep disturbance, window open (outdoor values), 60 dB L_{Amax}*	100

The survey found that:

- 69 per cent of respondents reported general satisfaction with their noise environment (i.e. liking the amount or absence of noise around them at home to some extent).
- 21 per cent of respondents reported that noise spoilt their home life to some extent, with 8 per cent reporting that their home life was spoilt either 'quite a lot' or 'totally'.
- With specific regards to road-traffic noise, 8 per cent of respondents were highly annoyed by road traffic.

There is a clear difference between the assessment of the onset of moderate annoyance using the WHO *external* noise guidelines and the response of residents in England and Wales. This suggests that internal guidelines are more likely to be a better indicator of people's quality of life.

UPDATED WHO GUIDELINES

Following many years of research, we now have a new set of guidelines, *Environmental Noise Guidelines for the European Region*,[1] published by WHO in 2018. These guidelines are exclusively external, so the internal levels are still current (see **Table 3**).

Interestingly the aircraft noise guidelines appear to be disproportionately lower than for road and rail. These guidelines have, however, been criticised: Gjestland[6] found that the selection of the dose–response surveys had a huge influence on the final guideline value suggested by WHO. (The dose is quantified by noise measurement or prediction. The response will vary depending on the study, from the annoyance response via social surveys to the risk of sleep disturbance from noise-induced awakenings.) A separate assessment of the various airport dose–response studies resulted in a guideline value of 53 dB L_{den}. This is consistent with 1999 guidelines for road and rail sources.

To put these numbers into context: we cannot, as before, compare these with population exposure data. Unlike the previous noise survey data in England and Wales, which were based on noise measurement at representative locations, we now must look at noise predictions using detailed 3D noise-modelling software. These noise predictions were carried out to comply with the Environmental Noise Directive, an EU-wide directive that requires member states to determine the exposure to environmental noise. The data from this noise-modelling exercise is available for all EU member states. This huge dataset can be used to track environmental exposure to noise across Europe over time. The data are not available to test on a like-for-like basis against the WHO 2018 guidelines. Instead, we have to use noise-modelling data for England that were published in July 2019,[7] based on exposure to levels ≥55 dB L_{den}. Approximately 11.5 million people (around 21 per cent of the population) are exposed to road-traffic noise levels greater than 55 dB L_{den}. The noise mapping exercise assesses populations in agglomerations (cities and large towns) as well as those near airports and main arterial roads and railways. As a result, this methodology may underestimate the population since the whole country has not been mapped.

In 2012, a *Noise Attitude Survey*[8] was carried out. Results were broadly consistent with previous surveys, indicating that a total of 8 per cent of people were very or extremely annoyed by road-traffic noise (the

Table 3. WHO guidelines (2018 and 1999)

2018 WHO guideline critical health effect	2018 level [external]	1999 level [internal]	1999 WHO guideline critical health effect
Road, daytime; 10 per cent absolute risk of highly annoyed population	53 dB L_{den}*	35 dB $L_{Aeq,16h}$**	Speech intelligibility and moderate annoyance
Rail, daytime; 10 per cent absolute risk of highly annoyed population	54 dB L_{den}	35 dB $L_{Aeq,16h}$	Speech intelligibility and moderate annoyance
Aircraft, daytime; 10 per cent absolute risk of highly annoyed population	45 dB L_{den}	35 dB $L_{Aeq,16h}$	Speech intelligibility and moderate annoyance
Road, night time; 3 per cent absolute risk of highly sleep disturbed	45 dB L_{night}***	30 dB $L_{Aeq,8h}$	Sleep disturbance
Rail, night time; 3 per cent absolute risk of highly sleep disturbed	44 dB L_{night}	30 dB $_{LAeq,8h}$	Sleep disturbance
Aircraft, night time; 11 per cent absolute risk of highly sleep disturbed	40 dB L_{night}	30 dB $L_{Aeq,8h}$	Sleep disturbance

*** and ** Unfortunately acoustic professionals and researchers like to use a bewildering quantity of metrics to describe sound levels, so the numbers in Table 3 do not provide like-for-like comparisons, as the 2018 noise guidelines use a dB L_{den} parameter, which merges the day (07:00–19:00), evening (19:00–23:00) and night-time (23:00–07:00) sound levels into a single number. L_{den} noise levels are around 2 dB higher than dB $L_{Aeq,16h}$ levels.[5] So the 2018 guideline for daytime traffic noise is approximately 51 dB $LA_{eq,16h}$ – practically the same level as the 1999 guideline for moderate annoyance outdoors (see Table 1).**

***** dB L_{night} indicates solely the night time (23:00–07:00) sound level.**

same as in 2000) and that 25 per cent were moderately, very or extremely annoyed by road-traffic noise (22 per cent in 2000).

HOW DO THESE GUIDELINES INFLUENCE THE BUILT ENVIRONMENT?

Generally speaking, the 2018 WHO guidelines correspond to an external environment where occupants can throw their windows open and not worry about being annoyed by noise. This is clearly a desirable scenario, but is it a practicable or economically feasible design target?

Compliance with these guidelines can be achieved in some cases for new buildings by selecting sites well away from any existing sources of transport, i.e. greenfield sites far from towns and cities. A conflict with the need for sustainable development near towns, cities and transport links becomes immediately apparent.

Noise reduction at source has improved over time. Cars are becoming quieter. With a move towards electric vehicles away from conventional petrol- and diesel-powered vehicles, the noise within towns and cities will reduce, albeit slowly. Rolling tyre/road noise becomes dominant at speeds over 55 km/h, so those exposed to sound from arterial roads will benefit less from any step changes in power train. Trains and aircraft have also reduced sound levels, but the reductions with improvements in technology are becoming modest.

Bunds, barriers and screens can provide significant reductions in external sound. These can be incorporated into the design of new roads and railways as well as being retrofitted. However, it is rarely possible to provide any useful reduction in noise for areas affected by aircraft noise.

Site layout can also be optimised to maximise the amount of incidental noise screening provided. Buildings where occupants are less sensitive to noise can be used to provide barriers to help protect other parts of a development, be they noise-sensitive amenity spaces and/or more sensitive buildings such as homes and schools.

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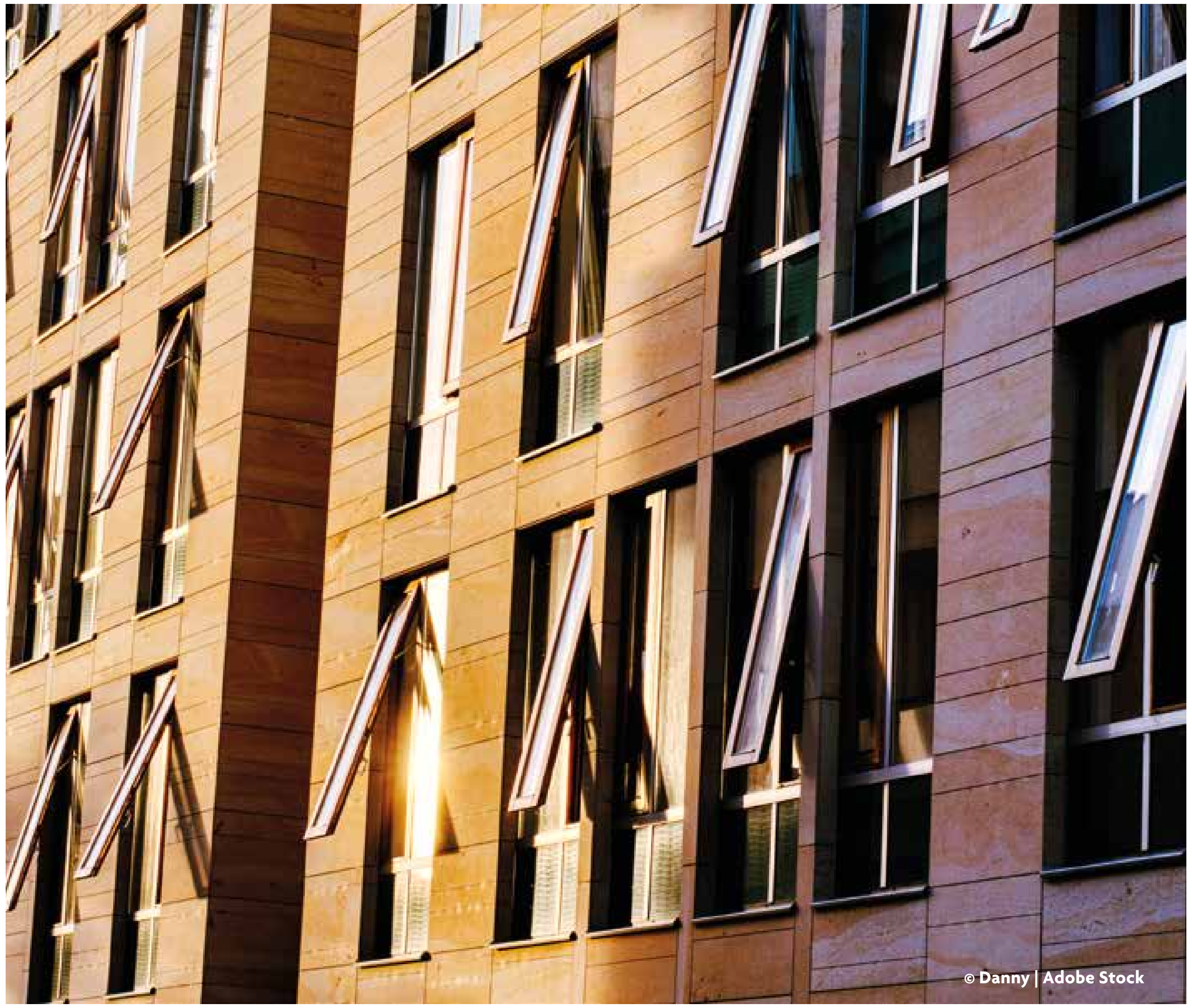
Despite all these options, it is still challenging to achieve recommended external guideline values for many urban and suburban locations. To enable a more pragmatic approach, it is more appropriate to consider the impact of noise on people inside buildings, and this is when acoustic consultants are often asked to provide design recommendations to meet desirable internal noise levels. However, this leads to another conflict in relation to the comfort of occupants between noise, indoor air quality, ventilation and thermal comfort.

Even in the noisiest and most-polluted areas of a city it is feasible to design homes with high levels of insulation against external sound. This can be supplemented with mechanical ventilation and air conditioning to achieve desirable comfort conditions for noise, indoor air quality and thermal comfort. In some countries this may be a typical design solution: in places such as Japan, South Korea and the USA, air conditioning is used in over 80 per cent of homes. However, air conditioning is not a sustainable design option, particularly when it may only be needed for a small part of the year, and many other countries do not routinely air condition dwellings.

WHAT DOES LONDON DO?

London provides an interesting case study for investigating how this design conflict (between acceptable thermal and noise comfort conditions) is being managed.

Changes in building standards designed to reduce CO_2 emissions have had unintended negative impacts. Modern thermally efficient and well-sealed dwellings have helped to improve the environment by reducing the amount of energy needed to heat a home during the colder parts of the year. However, these homes can



trap the heat during the warmest summer months, a problem made worse by the current trend to have very large areas of glazing.

Within central London, major planning applications require an assessment of overheating risk under a London Plan policy for climate change.[9] The policy is that development proposals should reduce potential overheating and reliance on air conditioning. This should be done via the following cooling hierarchy:

1. Minimise internal heat generation through energy-efficient design;
2. Reduce the amount of heat entering a building in summer through orientation, shading, albedo, the windows, insulation and green roofs and walls;
3. Manage the heat within the building through exposed internal thermal mass and high ceilings;
4. Passive ventilation;
5. Mechanical ventilation; and
6. Active cooling systems (ensuring that they are the lowest-carbon options).

Ventilation options can be constrained by the noise environment. Within excessively noisy urban environments, sound levels within dwellings based on passive ventilation systems may be unacceptable for occupants. There is a conflict between the need for ventilation to help cool a property and the need for acceptable acoustic comfort.

Currently, however, it is common to find that overheating risk assessments (carried out by building physicists) assume that the windows of homes can be left open during warm periods. The noise assessment, however, relies on windows being closed. Conlan and Harvie-Clark (2018)[10] found that when reviewing a large dataset of planning applications in London, 96 per cent of all noise assessments assumed windows were closed and 92 per cent of all overheating assessments assumed windows were open. This may not present a significant problem for more moderate noise levels. Occupants will ultimately make a choice between noise and thermal comfort. But with excessive sound levels this can result in poor-quality accommodation.

This is beginning to be addressed in the UK: the *Acoustics Ventilation and Overheating: Residential Design Guide* from the Association of Noise Consultants will provide, for the first time, objective guidance on how these risks can be assessed.[11]

INNOVATIVE SOLUTIONS?

Design solutions for excessively noisy sites that do not rely on energy-intensive mechanical ventilation and air conditioning are, at the moment, thin on the ground. Natural or hybrid ventilation solutions are being incorporated into a handful of new homes. They usually involve attenuated ventilation openings, such as large acoustic louvres, and/or mechanical ventilation rates that are significantly higher than Building Regulations minimums. These design solutions have been developed to meet objective overheating methods by building physics modelling. As far as the author is aware, little feedback is available on the satisfaction or comfort for the occupants of these innovative designs.

So where does this leave our 100 million people affected by traffic noise in the EU? With a view to meeting WHO critical health effects, substantial constraints would be needed in urban areas, such as:

- only electrically operated cars/buses/trams driving at low speeds;
- use of underground rail or low-speed above-ground electric transit systems to move people and freight; and
- airports located at a distance, with no aircraft flying anywhere near built-up areas.

This is exceedingly unlikely to make economic sense, although in the long term it is at least theoretically possible. With those low levels of sound, other day-to-day noise sources may become more prominent and more annoying. As will as the distant sound of the cock crowing from outside the city walls. **ES**

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REFERENCES

1. World Health Organization Regional Office for Europe (2018) *Environmental Noise Guidelines for the European Region.* Copenhagen: WHO Regional Office for Europe. http://www.euro.who.int/en/health-topics/environment-and-health/noise/publications/2018/environmental-noise-guidelines-for-the-european-region-2018
2. Berglund, B., Lindvall, T. and Schwela, D.H. (1999) *Guidelines for Community Noise.* Geneva: World Health Organization. https://apps.who.int/iris/handle/10665/66217
3. Building Research Establishment (BRE) (2002) *The National Noise Incidence Study 2000/2001 (United Kingdom): Volume 1 – Noise Levels.* London: Department for the Environment, Food and Rural Affairs; Cardiff: The National Assembly for Wales; Edinburgh: The Scottish Executive; Belfast: Department of the Environment for Northern Ireland. http://randd.defra.gov.uk/Document.aspx?Document=10280_NIS1206344f.pdf
4. Building Research Establishment (BRE) (2002) *The 1999/2000 National Survey of Attitudes to Environmental Noise – Volume 3 United Kingdom Results.* London: Department for the Environment, Food and Rural Affairs; Cardiff: The National Assembly for Wales; Edinburgh: The Scottish Executive; Belfast: Department of the Environment for Northern Ireland. http://randd.defra.gov.uk/Document.aspx?Document=10288_NNASVol3_UKResults.pdf
5. European Environment Agency (2010) *Good practice guide on noise exposure and potential health effects.* Copenhagen: EEA. https://www.eea.europa.eu/publications/good-practice-guide-on-noise/download
6. Gjestland, T. (2018) A systematic review of the basis for WHO's new recommendation for limiting aircraft noise annoyance. *International Journal of Environmental Research and Public Health*, 15 (2). https://www.ncbi.nlm.nih.gov/pubmed/30513834
7. Department for Environment, Health and Rural Affairs (2019) *Noise Exposure Data* – Round 3. London: Defra. https://data.gov.uk/dataset/d461bbc1-eb51-4852-8a9a-45dbf28aa230/noise-exposure-data-round-3
8. Building Research Establishment (BRE) (2014) *National Noise Attitude Survey 2012 (NNAS2012) Summary Report.* London: Defra. http://randd.defra.gov.uk/Document.aspx?Document=12378_SummaryReportV1.0.pdf
9. Greater London Authority (2016) *The London Plan 2016.* London: Greater London Authority. https://www.london.gov.uk/what-we-do/planning/london-plan/current-london-plan/london-plan-2016-pdf
10. Conlan, N. and Harvie-Clark, J. (2018) Using planning conditions to improve indoor air quality (IEQ) of new residential developments. *Proceedings of the Institute of Acoustics*, 40 (1).
11. Association of Noise Consultants (2019) *Ventilation and Overheating Guide.* Northallerton: ANC. https://www.association-of-noise-consultants.co.uk

CASE STUDY

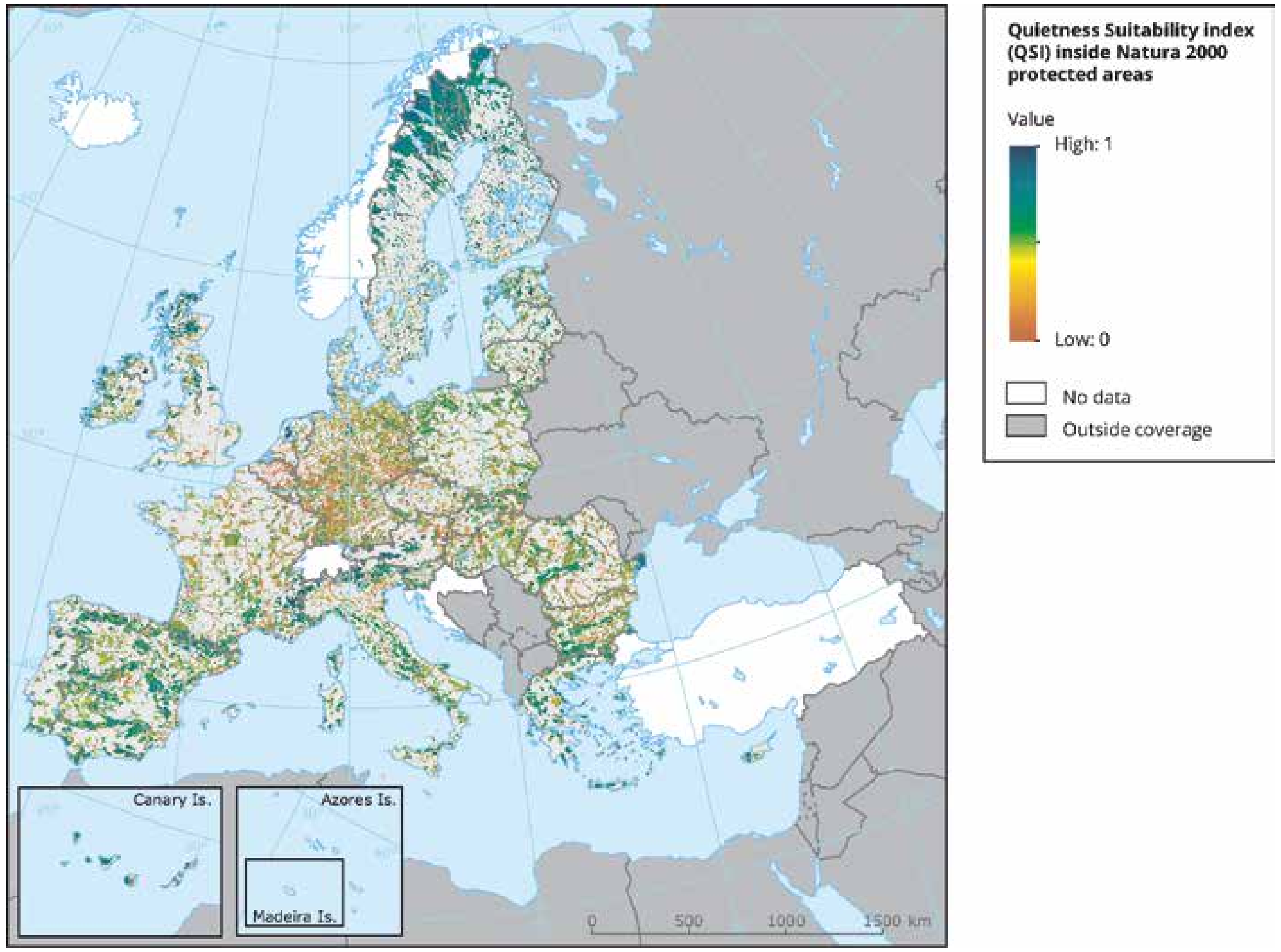
Quiet areas on the island of Ireland

Joseph Martin maps the growing idea of protecting areas from noise.

The European Environmental Noise Directive defines two kinds of quiet area. A quiet area in open countryside is delimited by national authorities as being undisturbed by noise from traffic, industry or recreational activities. A quiet area in an agglomeration means an 'area delimited by an action planning authority following consultation with the Agency and approval by the minister where particular requirements on exposure to environmental noise shall apply'.[1] The distribution of quiet areas is strongly related to population density and transport, which in turn are influenced by other factors such as elevation, distance from coastlines and land use.

MAPPING THE QUIET AREAS

In 2014, the European Environment Agency (EEA) published the *Good practice guide on quiet areas* and proposed a method for identifying quiet areas outside cities and towns using the quietness suitability index.[2] In 2016, the EEA built on the 2014 studies by mapping these quiet areas across Europe (see **Figure 1**). The data sources used were extensive and the resultant map shows large swathes of Europe that have the potential to be designated as official quiet areas. Most of these are located on the outer periphery of Europe due to the expansion of urban areas into the countryside. The mapping exercise found that approximately 18 per cent of Europe's area can be considered quiet but 33 per cent is potentially affected by noise pollution.[3] These maps can help to identify areas where action is needed to reduce noise and to identify and protect potential quiet areas.



▲ Figure 1. Potential quiet areas in Europe, as measured by the EU's quietness suitability index (QSI).[3] (European Environment Agency 2016)

THE BENEFITS OF QUIET AREAS

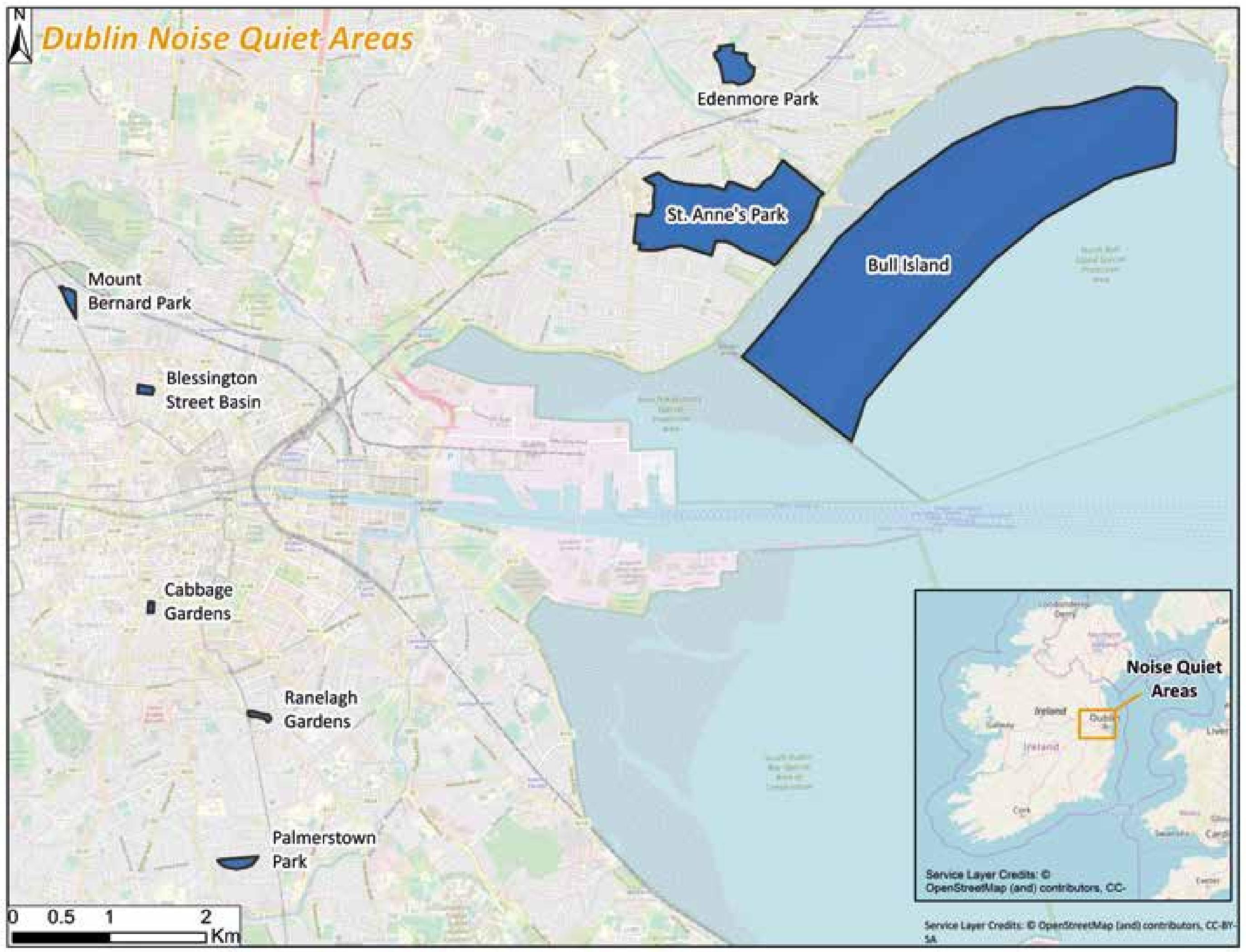
Health: one of the major advantages of designating quiet areas is the health benefits of these much-needed spaces. People living in quiet areas suffer fewer of the negative health effects commonly associated with exposure to the sound levels in major urban centres. According to Shepherd *et al* (2013), 'where direct comparative studies have been made of both quiet and noisy urban and rural areas, it is found that quality of life increases as noise levels decrease — health-related quality of life is highest in quiet rural locations'.[4] It has also been reported that having access to quiet areas within city locations is beneficial for those who live with illness or are recovering from health-related issues.

Biodiversity: one of the major causes of biodiversity loss is habitat destruction, and so the availability of quiet areas protects and enhances biodiversity levels. These zones of quietness work in tandem with existing designated ecological areas to ensure their continued protection under UK and EU law.[3]

Economic benefits: the desire to live and work in and around quiet areas is very high among the population of the UK, so designating parklands, for example, on the periphery of major UK cities attracts investment from housing and businesses (who then have to respect the quiet area), as well as providing indirect opportunities for employment and services.[3]

DUBLIN'S QUIET AREAS

In terms of designating quiet areas, Dublin was one of the leaders in Europe in attempting to limit noise impacts. On 24th July 2013, the Minister for Environment, Community and Local Government gave his approval for Dublin City Council to delimit eight locations as quiet areas (see **Figure 2**).[5] This was a highly progressive step, not just for Dublin but for other European countries, as it showed that noise areas were now being implemented within major urban centres and filtered into city planning guidance. In 2013, an Environmental Noise Action Plan for Dublin was also published,[7] and the significant actions included:



▲ Figure 2. Dublin's eight designated quiet areas. (Source: Rebecca Furlong/AECOM)

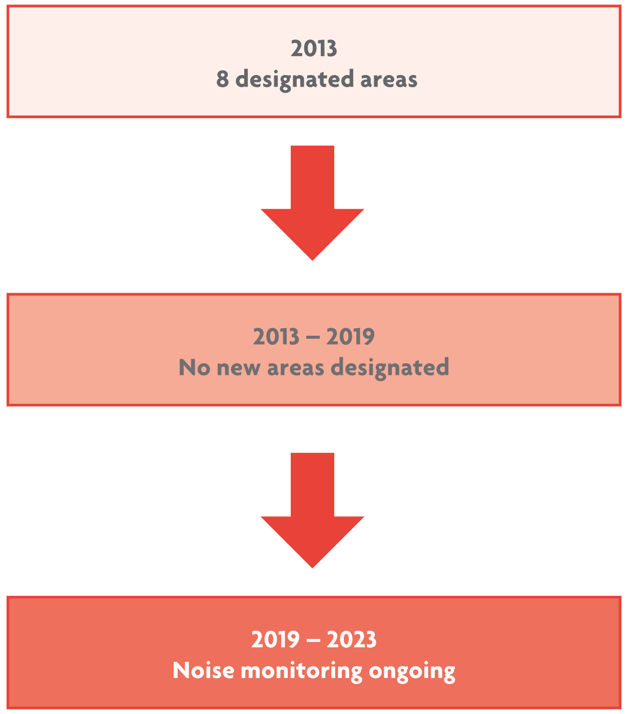
- Development of cycle greenways and shared pedestrian/cycle routes;
- Implementation of bus priority measures;
- Expansion of the Luas Network (Dublin's light rail/ tram service);
- Introduction of 30 km/h zones and traffic-calmed areas;
- Improvement of urban road network through improved traffic signal efficiency, allowing a smoothing of traffic flows on key strategic routes; and
- Removal of HGVs from non-strategic routes.

The eight quiet areas designated in 2013 were a continuation of a desire to limit excessive noise levels within the city of Dublin. Dublin's criteria for the chosen quiet areas were based around their own criteria and guidance from existing noise mapping for Dublin. The criteria included:

1. Public parks, with pathways, to which the public have right of access and that are maintained by Dublin City Council will be considered;
2. The L_{den} (day-evening-night noise level) for environmental noise within the area must be equal to or less than 55 dB(A), as indicated by the Dublin City Council Noise Maps (2011) of all road sources; and
3. A relatively quiet area will be considered if the difference between the L_{den} levels outside and within that area is 10–15 decibels or more.

Since 2013, Dublin has not proposed any new quiet areas, but it has continued to protect and collect ambient noise data on those eight locations throughout Dublin (see **Figure 3**), which is encouraging. However, there remain barriers to the delimiting of further areas, mainly due to land-use pressures in a rapidly growing city.

▲ **Lagan towpath, a potential quiet areas in Belfast. (K. Mitch Hodge | Unsplash)**



▲ **Figure 3. Dublin's quiet areas – in summary.**

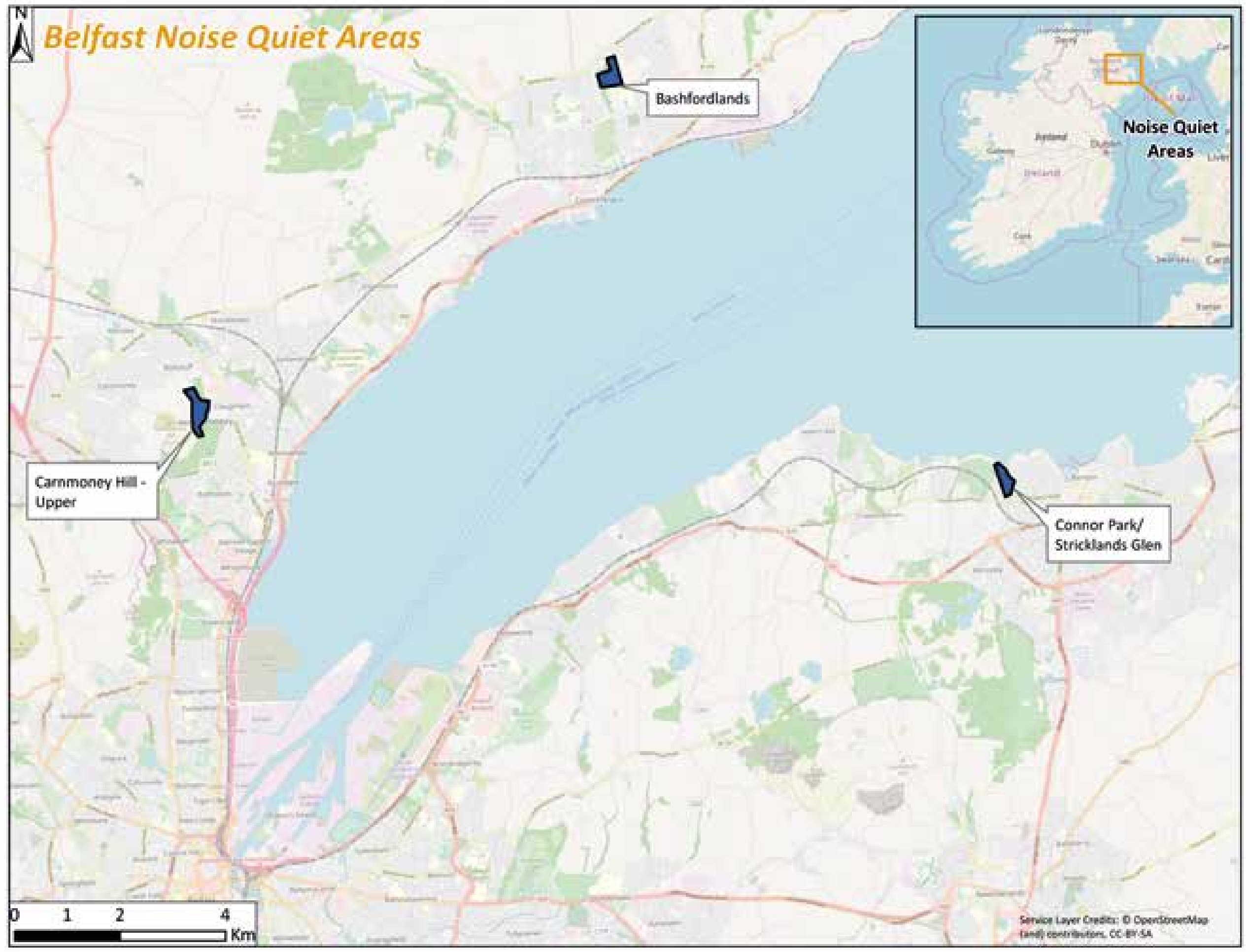
The second major Environmental Noise Action Plan for Dublin was published in 2018,[8] and it revealed that there have been small positive changes over the past five years in the number of people being exposed to undesirable sound levels, particularly at night, with a 2 per cent reduction in this category. However, 22 per cent of people are still being exposed to undesirable night-time sound levels. Traffic is the dominant noise source, with rail having little or no negative effects.

BELFAST'S QUIET AREAS

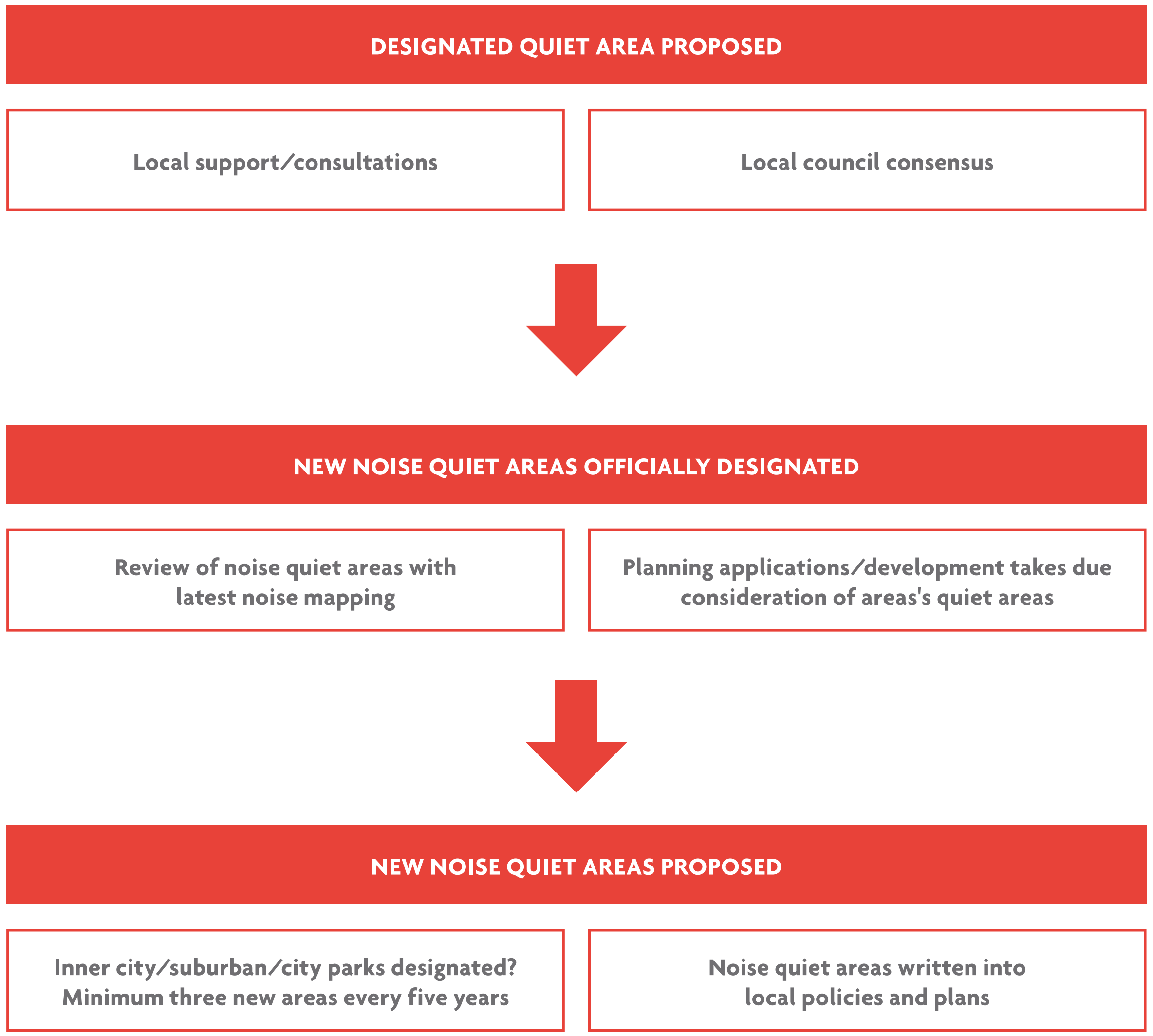
Another good example of designated quiet areas on the island of Ireland is Belfast, in Northern Ireland. In 2016, the Department of Agriculture, Environment and Rural Affairs (DAERA) published guidance on the identification, designation and management of quiet areas.[9] On 20th September 2016, three quiet areas were designated in Belfast:

- Connor Park/Stricklands Glen, Bangor West, North Down – 5.37 ha;
- Bashfordlands, Carrickfergus – 10.93 ha; and
- Carnmoney Hill – Upper, Newtownabbey – 16.70 ha.

As part of the Road Noise Action Plan 2018–2023[10] it was stated that quiet areas should also be protected and reviewed within local noise action plans on a regular basis. A review of the three existing areas has been undertaken since 2016 and subsequently one additional area, Lagan Meadows, has been put forward for consideration but has not been designated as of October 2019. The Noise Action Plan for Belfast also recommends noise limits and traffic-limiting measures as a way of protecting designated quiet areas.



▲ **Figure 3. Belfast's three designated quiet areas. (Source: Rebecca Furlong/AECOM)**



▲ **Figure 4. Potential all-island proposal for a quiet areas process.**

CASE STUDY

HAVE QUIET AREAS IN BELFAST AND DUBLIN SUCCEEDED?

The idea of quiet areas has been a successful one. The Noise Directive and EU guidance have assisted local councils to actively consider such areas within their plans and policies. Having quiet areas within or outside large urban centres, where people know they will be free from traffic and development pressures, is crucial to the development of a healthy population. These areas will become more important as the rural-to-urban migration trend continues, and urban sprawl puts additional pressures on green areas within large population centres.

However, problems do exist in designating further quiet areas. The first issue is that there is no consistent guidance on how to manage and monitor these areas once designated. The EU guidance is helpful, but many areas have their own pressures, whether they be traffic related or commercial/industrial land pressures that have limited local councils from going further and designating new areas for noise protection. Therefore, questions do remain. For example, why are all local parks in large urban centres not designated as quiet areas? Is it to do with development pressures and the fear of driving big business and large corporations away? How can local councils be incentivised to designate more quiet areas? In terms of Belfast and Dublin a consistent, joined-up approach may help (see **Figure 4**).

A JOINED-UP APPROACH TO DESIGNATING QUIET AREAS?

It is clear that there are many challenges in designating quiet areas within cities, as the examples of Belfast and Dublin show. A concerted effort by town and city councils is required to not only propose these areas but to protect and monitor their performances in line with their respective noise action plans. There does seem to be a reluctance to designate certain areas within cities, perhaps due to commercial and residential urban land-use pressures. This means that urban planners must do more to incorporate quiet areas in future city plans to ensure that our increasingly urban societies can rely on having communal quiet spaces.

ES

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REFERENCES

1. European Parliament (2002) Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise – Declaration by the Commission in the Conciliation Committee on the Directive relating to the assessment and management of environmental noise. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32002L0049 [accessed 26th September 2019].
2. European Environment Agency (2014) *Good practice guide on quiet areas*. Luxembourg: Publications Office of the European Union. https://www.eea.europa.eu/publications/good-practice-guide-on-quiet-areas [accessed 26th September 2019].
3. European Environment Agency (2016) *Quiet areas in Europe: The environment unaffected by noise pollution*. Luxembourg: Publications Office of the European Union. https://www.eea.europa.eu/publications/quiet-areas-in-europe [accessed 22nd September 2019].
4. Shepherd, D., Welch, D., Dirks, K.N. McBride, D. (2013) Do quiet areas afford greater health related quality of life than noisy areas? *International Journal of Environmental Research and Public Health*, 10 (4) pp.1284–1303.
5. Dublin City Council (2013) *Proposal to Designate Areas as Quiet Areas*. http://www.dublincity.ie/main-menu-services-water-waste-and-environment-noise-maps-and-action-plans/proposal-designate-areas [accessed 23rd September 2019].
6. Dún Laoghaire-Rathdown County Council (2013) Dublin Agglomeration Environmental Noise Action Plan December 2013–November 2018. https://www.dlrcoco.ie/sites/default/files/atoms/files/dublin-noise-action-plan-2013-2018-final.pdf.
7. Dublin City Council (2018) Dublin Agglomeration Environmental Noise Action Plan December 2018–July 2023. http://www.dublincity.ie/main-menu-services-water-waste-and-environment-noise-maps-and-action-plans/noise-action-plan [accessed 26th September 2019].
8. Department of Agriculture, Environment and Rural Affairs (2016) Policy Guidance on the Identification, Designation and Management of Quiet Areas. Belfast: DAERA. https://www.daera-ni.gov.uk/publications/guidance-quiet-areas [accessed 25th September 2019].
9. Department for Infrastructure (2018) Roads – Environmental Noise Directive Round Three – Road Noise Action Plan 2018–2023. Belfast: DfI. https://www.infrastructure-ni.gov.uk/consultations/environmental-noise-directive-road-noise-action-plan-2018-2023 [accessed 10th October 2019]

ANALYSIS

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Designing environmental soundscapes

Sarah Payne describes a project that puts users at the centre of research to find the best way of designing urban areas that promote health and well-being.

Environmental noise pollution is the second biggest cause of ill health in western Europe and sounds in the city are frequently referred to as noise, which means unwanted or unnecessary sound. Environmental sounds are generally discussed in terms of noise, including when students learn about environmental acoustics, academics run conference sessions on community noise, environmental health officers deal with noise complaints, the World Health Organization produces noise guidelines[1] and the European Commission sets the Environmental Noise Directive.[2] Yet within all of these areas of practice, there are also references to positive sounds, for example in the context of the designation and protection of quiet areas within the Environmental Noise Directive. Indeed, sounds in the city may be necessary or wanted, as they can provide vibrant city atmospheres or areas of tranquillity; city *sounds* are not necessarily *noise*.

ANALYSIS

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REFRAMING SOUND

Over the last few decades there has been a growing interest in an alternative approach to *describing* environmental sounds. Instead of focusing on environmental noise, there is the more neutral and person-orientated approach of soundscapes. This culminated in the International Organization for Standardization developing a soundscape definition: 'acoustic environments as perceived or experienced, and/or understood by a person or people, in context'.[3] This emphasises the individual subjective nature of the evaluation of the sound, and unlike the definition of noise, there is no direct evaluation in the term (such as wanted or unwanted). Indeed, 'soundscapes' could be the umbrella term for talking about evaluations of environmental sound, with the negative connotations of noise falling *within* this definition. This approach was also posited by the Chair-Elect of the Institute of Acoustics, Stephen Turner at a recent UK Acoustics Network workshop on soundscapes.[4]

This repositioning of how environmental sound is framed helps to broaden the research and policy focus from only being reactive and mitigating negative health outcomes to one that incorporates preventative health research involving positive health outcomes. This reframing also views environmental sound as a potential resource rather than solely a waste product. As the soundscape approach gained momentum, the Department for Environment and Rural Affairs (Defra) commissioned a report in 2009 into the concept and its practical and policy applications.[5] The report reflected on the few available urban design installations that creatively used sounds to develop a positive acoustic experience in the built environment. The idea of designing soundscapes that may be welcoming and enhance people's experience of an environment aligned with the Environmental Noise Directive, which requires cities to aim to protect quiet areas. This was, however, based on the assumption that quiet areas were important for people's health as they provided a refuge from 'noisier' areas in the city, rather than being beneficial *per se.* Indeed, there is limited research on the positive health and well-being benefits of visiting quiet areas or how to plan and design city environments to provide salutogenic (health-promoting) soundscapes.

PROJECT DESTRESS

Environments can support people's emotional and cognitive needs and provide a place to help them relax and recover from fatigue and stress, and the soundscape has an important role in providing that restorative experience. How to design urban soundscapes to provide a restorative experience, however, is less clear. Consequently, Project DeStress (Designing and Engineering Soundscapes To enable Restorative Environments for Sustainable Soundscapes), a research project led by Dr Sarah Payne at Heriot-Watt University, has started to explore what conditions help create quiet areas and how this relates to a restorative experience.[6] Initially, the research sought to explore the public's perception and identification of quiet areas to determine what creates them and whether they provide opportunities to restore, rest and relax. The Environmental Noise Directive suggests using objective sound levels such as L_{den} (the average day- and night-time sound level) to identify quiet areas. Perhaps this was proposed since quiet is the antonym of noisy, and noise is (perhaps wrongly, given its subjective nature) often assessed using acoustic metrics.

As predicted, the public did not define quiet areas based on sound levels alone. Instead, early analysis of the crowdsourced urban quiet areas suggest the types of sounds heard and the availability of greenery are important elements. This is in line with the approach taken by a number of European cities to identify quiet areas – they have used a number of criteria to identify quiet areas instead of just the average sound level. The physical land size, accessibility to the general population, amount of greenery and perceptions of tranquillity have all been used in urban quiet area identification in addition to average sound levels.

Contrasts between the public's perception of quiet areas and some city council designated quiet areas, however, were uncovered by Project DeStress's crowdsourced data. For example, in Edinburgh, a quiet area identified by the public included an inner courtyard in the city centre, just off a busy central street. This site did not meet the physical land size specification utilized by the Council to identify quiet areas (it was too small), yet was clearly important to some residents of the city. The public identified many other sites not listed for protection by the council. These differences emphasise the subjectivity involved in soundscape evaluations and the difficulty this may pose for how they are managed.

Understandably, not all sites identified by the public as quiet can be protected. For administrative ease, local council authorities may need to manage the protection rights of quiet areas by combining them with existing policies such as those for urban green spaces. However, awareness of public perceptions of quiet areas and engaging them in the official identification process is a useful mechanism for ensuring that places important for the public's well-being are protected. This was the approach taken by Brighton and Hove, which was also examined as part of Project DeStress.

CASE STUDIES

To further understand the relationship between people's use of public urban spaces, their soundscapes, and the health and well-being outcomes of visiting them, three sites were examined: an urban garden, an urban park and an urban square in three separate UK cities.


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These varied in objectively measured sound levels and the public's subjective evaluations of them as quiet. However, the restorative value of these places did not vary in line with the perceived or objective sound levels or their tranquil ratings.[7]

The most restorative places in a city may not necessarily be those with the quietest soundscapes. Despite the urban square having similar sound levels to the urban park, it had the lowest perceived quiet and tranquil ratings and lower levels of perceived restoration than the park. Additionally, the urban square was perceived to have significantly lower levels of biodiversity and perceived naturalness, while vehicle sounds were frequently heard in the square. In contrast, sounds of nature were frequently heard in the park and garden. Therefore, the type of sounds heard, and not just the sound level, are likely to have affected the restorative experience in the three sites. Indeed, different bird sounds are perceived as varying in their restorative potential;[8] some bird sounds are more relaxing and enable recovery from stress more so than other bird sounds. Water sounds can mask traffic sounds, so despite the addition of a water fountain, for example, which increases the overall sound level of a place, the soundscape is perceived as more relaxing. In general, research is starting to show that natural soundscapes are more restorative than urban soundscapes.

VIRTUAL ENVIRONMENT SIMULATOR

As we experience environments multi-sensorially and use environments in different ways and for different purposes, it is hard to disentangle the complex relationship of how a place results in positive or negative health and well-being outcomes. To help to establish the effect of each variable, such as the type of sound heard or the role of visuals or acoustics, research scientists use experimental manipulations to control some of these variables. Project DeStress developed an online virtual environment simulator to help determine the effect of sound and place type on people's urban space experiences and their health and well-being. The simulator is controlled by the user, who designs their own urban square or urban park by varying the amounts of vegetation, the number of people present and the number and type of water features; they can also choose what type of material the surrounding buildings are made of. It gives people the chance to see and hear the impact of decisions by architects and planners on how a place sounds and how it is subsequently experienced – its soundscape. By answering questions about how the place makes them feel and whether it contains characteristics that will enable psychological restoration, the user can reflect on how sounds may impact on their health and well-being.

It is hoped that the simulator will help the public become more aware of the positive (and negative) impact that soundscapes can have on their experience of a place and how the design of the built environment can influence those experiences. This in turn will enable them to engage in local built-environment decisions to help create positive, salutogenic environments and soundscapes in their neighbourhoods. Furthermore, as more people engage with the simulator and more controlled laboratory experiments are conducted, a better understanding of the relationship between soundscapes, psychological restoration and the built environment will emerge. ES

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REFERENCES

1. World Health Organisation Regional Office for Europe (2018) *Environmental Noise Guidelines for the European Region.* Copenhagen: WHO Regional Office for Europe.
2. European Parliament and Council (2002) Directive 2002/49/EC relating to the assessment and management of environmental noise. Brussels: Publications Office of the European Union.
3. International Organization for Standardization (2014) ISO 12913-1:2014. Acoustics–Soundscape–Part 1: Definition & conceptual framework. Geneva: ISO.
4. UK Acoustics Network (2019) *Videos from Soundscape Workshop in London, 25th of June 2019.* https://acoustics.ac.uk/events-past/videos-from-soundscape-workshop-in-london-in-june-2019/
5. Payne, S.R., Davies, W.J. and Adams, M.D. (2009) *Research into the practical and policy applications of soundscape concepts and techniques in urban areas (NANR200).* London: Defra, HMSO. http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=16391
6. Project DeStress. Edinburgh: Heriot-Watt University. https://DeStress.hw.ac.uk
7. Payne, S.R. and Bruce, N. (2019) Exploring the relationship between urban quiet areas and perceived restorative benefits. *International Journal of Environmental Research and Public Health.* 16 (9), p.1611.
8. Ratcliffe, E., Gatersleben, B. and Sowden, P.T. (2016) Associations with bird sounds: How do they relate to perceived restorative potential? *Journal of Environmental Psychology*, 47, pp.136–144.

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