Article

Progress in Human Geography
2017, Vol. 41(5) 618–637

DOI: 10.1177/0309132516652952
journals.sagepub.com/home/phg

Listening geographies: Landscape, affect and geotechnologies

Michael Gallagher
Manchester Metropolitan University, UK

Anja Kanngieser
University of Wollongong, Australia

Jonathan Prior
Cardiff University, UK

Abstract
This paper argues for expanded listening in geography. Expanded listening addresses how bodies of all kinds, human and more-than-human, respond to sound. We show how listening can contribute to research on a wide range of topics, beyond enquiry where sound itself is the primary substantive interest. This is demonstrated through close discussion of what an amplified sonic sensibility can bring to three areas of contemporary geographical interest: geographies of landscape, of affect, and of geotechnologies.

Keywords
affect, landscape, listening, more-than-human, sound, technology

> Everything that is resounds … The landscape resounds; facades, caricatures, halos, shadows dance across it. (Lingis, 1998: 100)

1 Introduction

This paper makes the case for radically expanding listening in human geography. Expanded listening refers to the varied ways in which bodies of all kinds – human and more-than-human – respond to sound. Drawing on insights from sound studies and sonic geographies, our aim is to encourage broader applications of listening in geographical research, on a range of topics. We discuss three areas where sonic sensibilities are already evident, or emergent, but where we hear particularly productive possibilities for extending them: in research on landscape, affect and geotechnologies. These are sequenced to work outwards from the dominant anthropocentric understanding of listening, beginning by deepening and expanding human listening (in relation to landscape), then considering how sound moves bodies beyond cochlear listening and human consciousness (as affects and atmospheres), and finally exploring forms of listening in which human bodies are marginal (vibrations in earth materials and machines).

Corresponding author:
Michael Gallagher, Faculty of Education, Manchester Metropolitan University, Birley Building, 53 Bonsall Street, Manchester M15 6GX, UK.
Email: m.gallagher@mmu.ac.uk

As the visual medium of text is not ideal for encouraging listening, we have provided audio clips of some of our examples.

In recent years there has been 'a veritable avalanche of scholarship devoted to the interconnections between sound and space' (Born, 2013: 4), including major works in the transdiscipline of sound studies (e.g. Augoyard and Torgue, 2008; Blesser and Salter, 2007; LaBelle, 2006, 2010). Across this literature, three overlapping themes can be identified. First, there is work that treats sound as a medium of knowledge, understanding listening as a 'hermeneutic disposition' (Revill, 2013: 58). Feld's concept of acoustemology (1996) frames sound as a distinctive medium for knowing the world, a notion that underpins research on such varied themes as the semiotics of music (Faudree, 2012; Henriques, 2011), the representational qualities of soundscape composition (Drever, 1999, 2002; Montgomery, 2009; Rennie, 2014), and the use of listening in producing medical knowledge (Rice, 2013), folklore (MacDonald, 2011), ornithology (Matless, 2000; Lorimer, 2007), and knowledge about particular places (Butler, 2006, 2007; Adams, 2009; Gallagher and Prior, 2014).

Second, there is scholarship addressing sound as a productive and performative force that creates spaces. Research has explored, for example, how sound organizes and reconfigures urban territories (Atkinson, 2007; Augoyard and Torgue, 2008; LaBelle, 2010), the use of sonic power in institutional spaces (Jones, 2005; Gallagher, 2010, 2011), and the role of sound art in the production of space (Pinder, 2001; Butler and Miller, 2005; DeSilvey, 2010; Gallagher, 2014, 2015a, 2015b; Revill, 2014; Montgomery, 2011).

Third, attention has been paid to the geographies of sonic affects, bodily sensations and emotions, within the wider turn towards post-phenomenological theories, in which listening is untethered from cochlear reception (Scrimshaw, 2013). Research has examined how sound moves bodies (Gallagher, 2016), including through various kinds of noise nuisance (Atkinson, 2007; Lorimer, 2013), sonic warfare (Goodman, 2009), and sonic affects in domestic and other everyday spaces (Anderson, 2004; Boyd and Duffy, 2012; Duffy and Waitt, 2013; Waitt et al., 2015). The emotional dimensions of listening in research encounters have been discussed (Bennett et al., 2015), as has the role of sonic affect in forming the self (Simpson, 2009). Other forms of sonic affect addressed by geographers include voices (Kanngieser, 2012), micro-radio (Kanngieser and Kogawa, 2013), and tinnitus (Atkinson, 2011; Ash, 2015).

Nevertheless, sound remains a neglected concern within human geography as a whole. Geographers routinely listen to and make sounds – during oral presentations, field trips, interviews and so on – but in most cases these practices are not adequately theorized or subjected to critical reflection. Despite all of the work reviewed above, it is still all too common for simplistic assumptions about sound and listening to be uncritically reproduced in geography. Listening tends to be understood in implicitly anthropocentric terms, linked to human consciousness and aurality (hearing through the ear). Other kinds of sonic encounters are frequently left out. For example, while a recent article on methods for animal geographies (Hodgetts and Lorimer, 2015) briefly refers to aural inter-species communication, no mention is made of the wealth of relevant work in wildlife sound recording and bioacoustics. Similarly, Oosterlynck and Swygedouw's (2010) research on struggles over aircraft noise in Brussels focuses almost exclusively on the underlying politics. Noise – a complex, contentious concept within the sound studies literature – is treated as a straightforward environmental pollutant, without any discussion or theorization. These articles are by no means unusual; they merely exemplify the marginal status of sound and listening within mainstream human geography.

As a discipline addressing the earth in all its diversity, geography needs to develop broader sonic sensibilities. Every space and place sounds and resounds, every living body and being vibrates, and every kind of material, object and surface has acoustic properties. Conceiving of listening in a narrowly anthropocentric way is wholly inadequate for understanding this profoundly polyphonic world. An expanded conception of listening concerns *the responsiveness of bodies encountering sound* – bodies of any and every kind, in different ways and contexts. The sound studies and sonic geographies literatures cited above have helped to enlarge the horizons of listening. Our aim in this paper is to bring these ideas and practices into other areas of geographical enquiry. The rationale for doing so is threefold.

First, expanded listening enables us to recognize that sound affects bodies, human and more-than-human, in ways that extend beyond human perception, cognition and knowledge. Perception and thought clearly play an important part in human listening, but using a universalized human consciousness as a guide for listening in its entirety – as though listening were only that and nothing else – creates an overly narrow field of enquiry. Expanded listening attends to any and every kind of kinetic oscillation, generating insights into the interrelations and flows between humans, animals, objects, technologies, materials, infrastructures, and environments. It has been suggested that such relations can be better understood using the metaphor of fluids rather than the networks of Actor Network Theory (e.g. Sheller, 2004); listening to sound, as waves moving through fluids such as air and water, is helpful for making this conceptual shift.

Second, expanded listening reveals things that are not available to other senses. Listening can reveal different aspects of visible spaces, as well as revealing elements that cannot be grasped through other senses, such as the embodied experience of music (Waitt and Duffy, 2010) and the propagation of vibrations across material thresholds (Ash, 2015). Sound 'inhabits space rather erratically and enigmatically' (Schafer, 1985: 88), with a tendency to escape from everyday temporal and spatial containers. Expanded listening helps us to understand this ephemerality and mobility. It positions sound not only as inherently spatial, but also as a force that disrupts and reworks common spatial concepts such as boundary, territory, place, scale, and landscape.

Third, expanded listening attunes to sound's capacity both to connect disparate bodies (LaBelle, 2006, 2010) and to change them (Kanngieser, 2015). Investigating the geographies of sound involves following chains of association across a range of spaces and corporealities, working transversally in a motion of propagation like sound itself. This movement reveals surprising or overlooked connections, and helps link together interests across geography.

Sound can be conceptualized in many ways – as object, wave, or event for example (see O'Callaghan, 2007). Rather than overly determining what sound 'is', we want to follow several threads regarding what sound might 'do' for human geography. To enable us to discuss a wide range of examples, we draw on different theorizations of sound and its relations with space. In acoustics, space is usually understood as a physical container or carrier for sound, with applied fields such as noise control and architectural acoustics using spaces to shape sound. Socio-cultural analyses, by contrast, often flip this logic around, listening to how sounds shape spaces by marking out territories (LaBelle, 2010), creating acoustic arenas (Blesser and Salter, 2007), generating affective atmospheres, and contributing to the production of space (Gallagher, 2014, 2015b). Revill (2015) has suggested that sound's spatiality involves the interplay of the phenomenology of listening, physical vibration in materials, and the meanings produced, such that all of these realms need to be considered simultaneously.

In particular empirical contexts, however, it may make sense to listen more closely to some of these elements than others. Rather than favouring any one theorization of sound and space, we want to recognize the different analytical functions they perform. If the object of analysis is, say, the affects generated by noise in buildings, then sound might be heard as a spatially disruptive force that transgresses boundaries and territories. Alternatively, if the aim is to explore how such noise is managed through architecture and design, it may be more useful to conceive of sound as waves moving within spaces, and examine how the material qualities of those spaces shape sound. Sounds both produce spaces and are produced by them, in all kinds of ways. Different conceptualizations of this relationship need not be mutually exclusive. They can be used selectively or in combination, as filters that attune analysis to different aspects of the matter at hand.

All of these themes stress the inherent complexity of sound. Sound simultaneously creates, reinstates and breaks apart boundaries, impressions, and associations. It does more than one thing; indeed it often does many contradictory things, at the same time, to many different bodies. This complexity cannot be shied away from; sound cannot be reduced to make it easier to understand, or tied down to a set of consistent functions across different domains. The ephemeral, fluid, mobile and relational qualities of sound, while difficult to pin down, need this difficulty in order to function productively. Rather than reducing sound to fit a narrow set of listening practices, those practices must be expanded to encompass the diversity and multiplicity of sound.

II An expanded concept of listening

In the social sciences, listening is predominantly orientated towards the human. This focus is evident in research practices which explore what people have to say about their lives (Back, 2007; Gallagher, 2013), phenomenological accounts of how sound is experienced (Ingold, 2007), and notions of listening as a conduit for understanding the self (Nancy, 2007) or as intersubjective exchange (Bennett et al., 2015). Such perspectives generate important insights, but they struggle to address the full potential of listening to extend beyond the human to engage with other forms of life. Geography's concern with the earth as a whole points towards the need for an expanded conception of listening, as the responsiveness of bodies and materials encountering sound. Bodies, in this formulation, include human and more-than-human entities, while materials could include everything from microscopic particles to large-scale landforms. Our interest is not simply in how sound moves through these bodies and materials. Rather we are concerned with those situations where bodies and materials become particularly responsive to sound, resonating, amplifying or relaying vibration – situations where sound makes a difference in some way. Expanded listening starts with the ear, but goes beyond it to include the whole body. It also acknowledges forms of responsiveness to sounds that cannot be 'heard' by humans, whether due to frequency range (sounds below 20 Hz or above 20 kHz), amplitude (very quiet or deafeningly loud), temporality (sounds which take place within microseconds or over long spans of time), or spatiality (such as sounds beneath the earth's surface or in the atmosphere).

Revill (2015) cautions that listening risks downplaying other important aspects of sound, such as its relations with materials. We propose that it is possible, however, to attune to the multiplicity of sound not by moving away from listening, but by radically expanding it. Expanded listening addresses many different registers of sound: aesthetic, compositional and timbral qualities; affective, material and embodied characteristics; the ways in which sound is both spatial and temporal, evoking a sense of time, distance, direction or movement; sound's capacity to produce knowledge of events and

processes; and the semiotic associations produced by listening, including the tendency of sound to trigger memories.

Listening is often distinguished from hearing, with the former positioned as conscious attention and the latter as a more passive form of reception; as Handel writes, 'the physical pressure wave enables perception but does not force it. Listening is active; it allows age, experience, expectation, and expertise to influence perception' (1989: 3). Perception is here understood to be 'the necessary second stage [after sensing]. . . . During perception, the conception of an external event is constructed' (p. 3). A variety of different listening modes can be identified that pertain to such human perception. For example, Chion differentiates between causal listening, 'to gather information about [a sound's] cause (or source)' (1994: 25), semantic listening, aimed at the interpretation of the meaning of sounds, as with spoken language for example, and reduced listening, which 'focuses on the traits of the sound itself, independent of its cause and of its meaning' (p. 29). Meanwhile, Truax discriminates between 'listening-in-readiness', wherein a listener is in a state receptive to receiving certain sounds, but whose attention lies elsewhere (Truax provides the example of a mother woken by a baby's cry but not by road traffic), and 'listening-in-search', which involves consciously listening to sounds for 'cues' (1984: 19).

We think there is something worth holding onto about listening, as a range of dispositions and activities that are more clearly responsive than what is usually referred to as hearing, but we take issue with how listening tends to be restrictively tied to human consciousness and intentionality. This is not to deny that human consciousness plays an important role, including in many of the examples we discuss below; the problem is rather the tendency to think that listening is *nothing but* an activity of human consciousness. In qualitative social research, for instance, this conception has led to listening becoming merely a metaphor for interpretation, emptied of any sensibility for sound as such (e.g. Clark and Moss, 2011: 9).

Our aim, by contrast, is to think about what else listening might be, and so we posit it as a spectrum of different kinds of responsiveness that includes but also goes beyond active human audition. Expanding outwards from the human, listening can be theorized as encompassing, for example: the ways in which animals respond to sound; the electro-mechanical responses of listening technologies, from telephones to ultrasound scanners; or the ways in which seemingly inert materials are disposed to 'pick up' and respond to certain kinds of sonic vibration, as when passing traffic rattles buildings, or aircraft sonic booms shatter windows. It may seem curious to consider such sonic encounters as instances of listening, but if we take seriously post-humanist and multispecies propositions (Descola, 2013; Haraway, 2003; Whatmore, 2002), it is no longer tenable to privilege a particular subset of human responses to sound over other kinds of responses by other kinds of bodies and materials. Expanded listening does not remove the human, but rather allows other things to flood in as well.

In expanded listening, bodies reveal themselves as malleable and porous, and in some cases, highly susceptible to sound. As Catherine Christer Hennix (2015: unpaginated) suggests, we would do well to 'consider the listener as a dynamical soft condensed matter system far from equilibrium and whose internal signal path and transmission systems can be tuned by exposure to external sound sources'. Developing listening practices may therefore be less about becoming newly responsive to sound, and more about attending more closely to responses that are already happening but which normally pass unnoticed; put another way, listening to bodies listening.

A notable risk of expanded listening is that in embracing polyphony the possibilities for analysis become overwhelmingly diffuse. Our response, in the remainder of the paper, is to

focus enquiry on particular instances of listening, to particular sounds, in particular locations. The aim is not to further advance general theories about sound's spatiality, but rather to map out what closer listening can bring to particular areas of geographical enquiry. We have identified three areas in which a sonic sensibility is already established or emerging, but in which we hear productive possibilities for expanded listening: in work on landscape, affect, and geotechnologies. Working through these themes enables us to expand outwards from the dominant anthropocentric position. We begin by exploring how human listening could be deepened and extended as a way to rethink landscape. A focus on sonic affect and atmospheres then expands listening beyond human perception, cochlear listening, and consciousness, to how sound impinges on bodies, including (but not limited to) human bodies. Finally, we examine forms of listening in which humans are more marginal, including vibrations amongst other animal species, in earth materials and vibration-sensing technologies.

III The sounds of landscape

As a fundamental organizing principle within geography, 'landscape' has been most thoroughly conceived of and attended to along visual lines of inquiry, to the point where geographers have been forced to ask: are the visual surface qualities of landscape, as perceived by a physically distant observer, all landscape is (see Wylie, 2007)? This enduring question has been met with a variety of responses from scholars both inside and outside of geography. Some have tried to disentangle the (contested) etymological roots of landscape to help understand its essential nature (Bourassa, 1991; Evernden, 1981; Olwig, 1996; Scazzosi, 2004); some have emphasized the embodied qualities of being and dwelling in landscape as a corrective to the assumed distancing effect of viewing landscapes from afar (Berleant, 1992; Ingold, 2000); while others have defended looking at landscapes, particularly from a scenic perspective (Benediktsson, 2007; Lowenthal, 2007; Parsons and Daniel, 2002).

A few geographers have addressed the sonic qualities of landscapes. For example, Matless (2005) has examined how the regulation of 'noisy' human sounds is central to the construction of 'natural' regions. Here, sound offers a way of investigating landscape-related values and epistemologies, while revealing the widely-held attitude in soundscape management that quietude is universally desirable. This attitude underpins attempts at the top-down regulation of human and mechanical sounds in natural landscapes – a common focus in landscape research outwith geography (see for example Lynch et al., 2011; Miller, 2008) – and also in urbanized landscapes through noise control policies and noise abatement campaigns. There have also been more nuanced approaches to 'noise' that point to how aesthetic appreciation or depreciation is highly variable and context specific, while at the same time taking the human and more-than-human health implications of excessive noise seriously. Adams et al. (2006) demonstrate that supposedly objectionable sounds in urban landscapes, such as all-night parties and the 'hum' of traffic, are tolerated or even aesthetically appreciated in certain contexts (see also Raimbault and Dubois, 2005). LaBelle (2010: xxiii) neatly sums up the resulting tension: 'on one hand there is no denial as to the intensities with which noise interferes with personal health and well being, while on the other hand noise may be heard as registering a particular vitality within the cultural and social sphere'. Addressing this tension, the Positive Soundscapes project has explored how urban landscapes might be designed to sound better, rather than simply sound less (Davies et al., 2013).

Revill (2014) approaches landscape from a different angle, examining an audio work produced by sound recordist Chris Watson derived

from recordings of a now-defunct railway line in Mexico. Revill seeks to account for how sound 'participates in the production of the railway corridor as a complex, animate and deeply contoured historically and geographically specific experience of landscape' (2014: 333). The complexity and multiplicity of landscape sounds is also evident in Lorimer and Wylie's (2010) performative evocation of a walk through rural Wales. Here, sounds charm, plague and bemuse; the walkers encounter prosaic sounds and strange sounds, sounds that prompt active listening and imagination, and others that merge into a background fuzz.

The work outlined here broadens the scope of what constitutes 'landscape' in geographical research, and demonstrates that sound is a vital attribute of landscape and landscape experience. In what follows, we go further by thinking through some of the distinctive qualities of listening within landscapes, and their implications for geographical scholarship.

Firstly, when listening within any given landscape, it is apparent that the spatial qualities of sound are unlike those of light. Indeed, how sound behaves in relation to physical spaces – in terms of resonances, reflections, echoes, diffusion and absorption – is different to the behaviour of light (Blesser and Salter, 2007). What we are listening to may not emanate from those components that we can see within a visually discrete landscape; instead, we may be picking up sounds emanating from adjacent or distant landscapes. Empirical landscape research has demonstrated the tremendous difficulty – if not impossibility – of trying to implement forms of landscape design so as to prevent sounds from crossing cultural, ecological, or geological landscape thresholds (Prior, 2012). This, in effect, dissolves the discrete, internally coherent qualities of landscapes that are so often taken for granted when landscape is conceptualized through vision and visuality, regardless of whether landscape is understood materially or as a way of seeing or being. This discreteness is invoked in many theoretical and practice-based approaches toward landscape, such as when landscape designers and architects speak of and measure 'viewsheds' delineating the perimeter of landscape (Ervin and Steinitz, 2003; Motloch, 2001: 190; Smardon et al., 1986), or when spatial scientists map, model, and classify landscapes using GIS techniques. The temporal dimensions of sounds and sounding events – often fleeting, ephemeral, dynamic, and unstable – compound this dissolution of landscape discreteness, and with it the ability to frame sonic landscape experience (see Fisher, 1998: 173–4). Attending to landscape through listening can thereby destabilize the very concept of landscape as a specific, identifiable space.

Secondly, while listening in a given landscape, we may also become aware of how there is often a spatial mismatch between the size of an object or subject from which a sound emanates and the spatial scale of the auditory space that the sound resonates within and fills (e.g. insects and birds in a meadow [audio: birds-in-meadow.mp3]). Such resonance within a landscape depends not only on the amplitude of a sound relative to other sounds, but also its pitch, directionality, rhythms, and duration, and the material and spatial qualities of the landscape. As sounds resonate, they can promulgate the spatial dynamics of landscape, revealing spatial contours as well as various material qualities of landscape surfaces – particularly how surfaces may influence the reception of sounds through reflection and absorption (e.g. oystercatcher vocalizations reverberating across the hard surfaces of a rocky beach and cliffs [audio: oystercatchers.mp3]). Listening provides an additional channel of knowledge, producing insights into scale, materiality and landscape morphology that are not available through other ways of knowing.

Thirdly, as well as sensing reflections from surfaces, it is possible to listen to sounds that originate from beneath visible surfaces of a

landscape. This listening may augment human auditory physiology with various technological intermediaries, such as geophones to listen to subsurface ground movements, or contact microphones to listen to the internal vibrations of a bridge spanning a landscape [audio: bridge-contact-microphone.mp3]. At other times, sounds produced below a surface may cross this visible threshold, as when listening to a bird call that originates at the syrinx within the bird's body. Listening can also detect sonic landscape components not detectable by the eye (e.g. the sound of electricity running through an overhead power line [audio: overhead-power.mp3]). This ability to simultaneously listen to the inside and outside of sounding objects and subjects within landscapes complicates any simple bifurcation of landscape between surface and depth. Thus, a thoroughly conceived sonic geography of landscape that attends to listening cannot privilege one over the other, challenging critical scholars who valorize depth over surface (see Forsyth et al., 2013) as a supposed corrective to the tendency within the geographical literature of focusing only on landscape exteriorities.

IV Sound, atmospheres and affect

The capacity of sound to move bodies is of central importance to us in expanding listening beyond human perception and cognition; of interest is how feedback loops between sound, space, infrastructures, matter and bodies generate listening responses. Sound produces affective atmospheres, which interface with bodies on auditory and other listening registers (Adey et al., 2013; Anderson and Ash, 2014; Duff, 2010; McCormack, 2008). Affect, write Gregg and Seigworth (2010: 1), can be thought of as

> an impingement or extrusion of a momentary or sometimes more sustained state of relation *as well as* the passage (and the duration of passage) of forces or intensities. That is, affect is found in those intensities that pass body to body (human, nonhuman, part-body, and otherwise), in those resonances that circulate about, between, and sometimes stick to bodies and worlds, *and* in the very passages or variations between these intensities and resonances themselves. Affect, at its most anthropomorphic, is the name we give to those forces – visceral forces beneath, alongside, or generally *other than* conscious knowing, vital forces insisting beyond emotion – that can serve to drive us toward movement, toward thought and extension, that can likewise suspend us (as if in neutral) across a barely registering accretion of force-relations, or that can even leave us overwhelmed by the world's apparent intractability

Thus, affect is more than feeling or emotion. It is better thought of as forces that impinge on bodies, which may or may not be felt. Sound, as physical vibration, is affective (Gallagher, 2016). It acts contagiously to modulate a dance floor, to repel bodies from alarms and sirens, or to innervate a wave of response during a vivid filmic scene. The affective aspect of sound comes precisely from the relations, exchanges and movements between bodies and environments. Sound therefore has the extra-individual, miasmatic qualities of what geographers have called affective atmospheres (Bissell, 2010). According to Anderson (2009: 78):

> atmosphere traverses distinctions between peoples, things, and spaces. It is possible to talk of: a morning atmosphere, the atmosphere of a room before a meeting, the atmosphere of a city, an atmosphere between two or more people, the atmosphere of a street, the atmosphere of an epoch, an atmosphere in a place of worship, and the atmosphere that surrounds a person, amongst much else. Perhaps there is nothing that doesn't have an atmosphere or could be described as atmospheric. On the one hand, atmospheres are real phenomena. They 'envelop' and thus press on a society 'from all sides' with a certain force. On the other, they are not necessarily sensible phenomena.

For Anderson, given this difficulty of definition, we might consider atmospheres as 'spatially discharged affective qualities that are autonomous from the bodies that they emerge

from, enable and perish with' (2009: 80). To think of affective atmospheres is to think affect into spatial and material realms.

Sound is critical to affective atmospheres for two reasons. First, it moves through space in distinctive ways. Sound is highly promiscuous (LaBelle, 2010: xvii); while it travels through materials differentially, in air it has a tendency to envelop other bodies. Because of this fluid, diffusive and immersive tendency, sound is integral to the formation of atmospheres in spaces. Second, everything participates in the sounding of worlds, including both biotic and abiotic bodies – an exhale, the teeming of insects, the movement of fabric, a chemical reaction, the oscillation of leaves and branches [audio: leaves-branches.mp3], an echo off concrete, a riot, a boat idling [audio: boat-harbour.mp3], ice thawing and so forth. Because everything engages sound, sound acts to link and collectivize bodies and environments, creating different kinds of atmospheres. These sounds may be audible or inaudible to the human ear, or on the threshold of audibility. The vibrational force of sound means that it acts upon entities regardless of whether those entities are consciously listening to it or not.

Working within and through spaces, sound creates affective atmospheres via vibrations, pitches, volumes, frequencies, harmonies and disharmonies. These sounds can be conducive to particular psychosomatic states in listening bodies. For instance, in humans, low frequencies have a tendency to produce queasiness, while oceanic rhythms may have calming affects. Such embodied responses may be understood through a visceral approach to sound, recognizing how sound produces physical intensities or 'gut feelings' (Duffy and Waitt, 2013; Waitt et al., 2013, 2015). Sound pervades environments in excess of, and irreducible to, any individual or group, destabilizing the notion of an individuated, 'conscious', listening subject. Expanded listening is affective: coming prior to cognitive and discursive comprehension, independent of 'bodily modes' and indifferent to emotional products (Deleuze and Guattari, 1988, 1994; Massumi, 2002). What is critical in this kind of listening, in terms of affect, are the ways in which sounds defy recognition and categorization into feeling and narrative while being implicated within them.

The vibratory and affective nature of sound challenges the common assumption that listening is contingent on aural receptivity. In geography, this insight has the potential to extend thinking on governance and spatial control by drawing attention to those *heard-felt* registers in which sound can affect bodies, sometimes profoundly, but which fall outside the ranges of human perception and consciousness. In debates about 'noise' pollution, much has been made of the human inability to not hear, or to 'shut our earlids' (Schafer, 1977). Sound, however, is also sensed and listened to through the skin and within bodily cavities, organs, and cells. Listening is thus an embodied practice, forcing us to consider 'non-cochlear' (Kim-Cohen, 2009) sonic geographies, in which sounds are spatialized across bodies. This is especially the case with sub- or in-audible sounds that cause disturbances, even though affected individuals are often unable to pinpoint precisely why, or how, bodies are affected. Vibro-acoustic effects do not necessarily announce themselves on the level of conscious listening.

One example is low frequency noise (LFN), sometimes referred to as 'the hum' (examples may be heard here: http://bit.ly/1otPx8o). This 'hum' is sensed by a minority of people, clustered in specific locations, who complain of being disturbed by a low frequency droning sound that is often inaudible or barely audible to others, and difficult to register in audio recordings and noise measurements.

> While only a relatively small number of people are affected, those who are tend to suffer severe distress ... and they may suffer various symptoms such as depression or even feel suicidal. In

> some cases a source of LFN is found and can be dealt with. However, in many cases ... no environmental sound that could account for the sufferer's reaction can be found, and the cause of the disturbance remains a mystery. (Moorhouse et al., 2011: 2)

Such phenomena demonstrate the complex entanglements of sound being heard, felt, and listened to, affective atmospheres, and emotional states. The atmospheres created by sonic environments, and the corresponding neural, emotional and physical reactions – particularly those derived from anticipatory response – agitate bodies, which at the same time recompose atmospheric affects. That is to say, bodies, in varying degrees of intensity, charge and change how atmospheres 'feel', and what they do. Consider how a space might 'vibrate' after a loud retort has echoed, or a street might still hold the sonic memory of a recently passed demonstration.

Sonic affects are especially acute where listening is deployed for strategies of sonic governance and warfare (Goodman, 2009): the use of forensic audiology by the UK Border Agency to identify asylum seekers' places of origin through listening to accent, dialect and other sonic characteristics; voice biometrics as deployed in logistics distribution centres and incarceration processes to listen to and map movement; the increasing ubiquity of automated voice systems in public spaces (e.g. safety and security announcements in travel hubs [audio file: automated-announcements.mp3]); and the normalization of listening posts and covert microphones in public spaces. These examples point to a growing industry for expansive forms of listening, surveillance, sound, and voice technologies in regimes of spatial control (Kanngieser, 2013). The affectivity of these technologies arises in part from certain vocal timbres – the ubiquity of female voices as automated public announcements for instance, as Nina Power points out (2013) – and from the power ascribed to voice-sensitive technologies to listen to, and 'read', competency, emotion, nationality, and ethnicity through sound.

Technologies of acoustic warfare also deserve consideration here because of the harm they cause via expanded forms of listening. The manifestation of sound as weaponry through symbiotic military and commercial application is customarily shrouded in speculation, in part to do with the amorphous and acousmatic character of sound. The use of sound and music in psychological warfare as a means of interrogation and torture, whereby volume and repetition are used to overwhelm listeners, has been critically documented (Hill, 2012; Cusick, 2006, 2008; Pieslak, 2009), along with developments in acoustic technologies designed to stun, disperse, intimidate and control civilian populations. These include flash bang grenades which produce sound pressure levels of around 170dB(A) (a level at which immediate physical damage can occur); sonic booms from military jet planes used as a show of force, such as around US air bases in Japan (Cox, 2010) and in the Occupied Territories of Palestine; gas cannons designed to scare birds away from agricultural crops, aerodromes, and aquaculture facilities (Lorimer, 2013); ultrasonic devices for dispersing young people from public spaces (Gallagher, 2016), or repelling animals such as rodents and pigeons; and Long Range Acoustic Devices (LRADs), which have been adopted for civilian policing. In 2009, at the G20 summit in Pittsburgh, an LRAD, or sound cannon, mounted on a police tank was notoriously used to dispel protesters, who were unable to block out the loud and extremely high pitched alarms [audio: lrad.mp3] (Feigenbaum and Kanngieser, 2015). LRADs, sonic booms, and flash bang grenades have all been documented to cause severe effects ranging from sweating, dizziness, disorientation and deafness, to miscarriages, and long-term anxiety and psychosomatic disorders (Feigenbaum and Kanngieser, 2015).

Alongside sonic technologies that operate through volume are persistent rumours of

infrasonic and ultrasonic devices, using frequencies at or beyond the extremes of human hearing, but well within the hearing range of other animal species (Vaisman, 2002). While we will discuss the physicality of infrasound in more detail in the following section, here we want to stress the affective capacity of such devices to engender anxiety and fear (Goodman, 2009), due to the potential of sound to be inaudibly instituted as a technique of nation-state governance and violence. Ongoing concerns around the developments of 'silent' but fatal technologies such as VLF modulators, 'sound bullets' and directional sound beams such as the 'voice of god' weapon, haunt military literature and online forums.

It is precisely this play with perceptibility that contributes greatly to the affective atmospheres that sound invokes, and which requires a concept of listening that goes beyond human consciousness. While affective atmospheres are tied to bodies, they are clearly not only tied to human bodies; all matter is affected by sound in some way. In his text on non-cochlear sound, Scrimshaw proposes a scission of affect from 'the necessity of subjective affirmation' (2013: 28), to emphasize the nature of sonic affects and signals in excess of their human audibility or perceptibility. This echoes Cox's (2011) call for a sonic materialism, in which sound is considered beyond its attributed phenomenological immediacy, individuality and symbolism. Hearing sound, and listening, from this expanded perspective, brings to debates on geographies of affect a clear avenue for understanding how bodies, materials and environments can interact and interrelate, without anthropocentrism and the reduction to a universally 'human' experience (Gallagher, 2016).

V Geotechnologies

Following on from these arguments, we want to argue that sound has particular relevance for geographers due to its capacity to connect humans to many other kinds of entities, materials, and processes, including the bodies of animals and plants, water and weather systems, landforms, seismic activity, and all kinds of sonic technologies. Jackson and Fannin (2011: 436) argue that the expansion of interest in materiality requires more careful listening to the 'multiple and interrelated voices' of matter, but in their account listening remains metaphorical. In relation to the sonic aspects of more-than-human life, Matless (2000) and Lorimer (2007) have written about Ludwig Koch's pioneering bird sound recordings, yet much of the nature-culture literature is silent about sound. In this section, our discussion goes further beyond the human to consider what can be gained by listening in an expanded way to the relations between audio technologies, materials, animals, and geophysical phenomena, grouped together under the term geotechnologies.

As we have already noted, the science of acoustics conceives of sound as mechanical waves propagating through materials:

> When the molecules of a fluid or solid are displaced from their normal configurations, an internal elastic restoring force arises. It is this elastic restoring force, coupled with the inertia of the system, that enables matter to participate in oscillatory vibrations and thereby generate and transit acoustic waves. (Kinsler et al., 2000: 1)

Thus, whilst sound may not be material per se (Ingold, 2007), it is closely bound up with materials. Sound requires matter to vibrate in and through, and materials shape sound through their physical properties. Sound waves may be amplified by the resonances of materials, attenuated through absorption, or reflected as reverberation, with marked effects on the atmosphere of a space (e.g. voices echoing in a stone stairwell, compared with voices being absorbed in a cork-lined space [audio file: reverberant-absorbent.mp3]). These relations between sound, space and materiality are significantly different to those of light, as we have discussed

in relation to landscape. Light is capable of passing through a vacuum and tends to be impeded by materials, whereas sound propagates more efficiently through denser materials. Attending to sound can therefore generate distinctive knowledge about the earth's materials and physical processes, particularly where these are hidden from view. Conversely, and perhaps more importantly, tuning in to such vibrations brings an awareness of how thin the bandwidth of human audition is, and of how much action completely bypasses the human senses.

The emergence of sonic enquiry into earth systems is closely allied to developments in audio technologies and geopolitics. The field of marine acoustics, for example, grew out of the intersection between oceanography and military engineering. During the Cold War the US Navy created the Sound Surveillance System (SOSUS), an array of hydrophones around the Atlantic for the long-range detection of Soviet submarines, based on the physics of deep ocean channels propagating low frequencies across long distances. It was later repurposed for civilian scientific listening, including monitoring submarine volcanic activity and blue whale movements (Wolman, 2002; listen to examples: http://youtu.be/bgWwx_5WsIo). Sonar and other audio technologies are now routinely used for bathymetry (Chakraborty and Fernandes, 2012), oil exploration, the surveying of fish populations, the measurement of ocean currents using acoustic Doppler shift, the assessment of underwater noise from shipping (Merchant et al., 2012) and for research on glacial processes (Tegowski et al., 2011). Seismic monitoring can similarly be understood as an expanded form of listening to sound beyond or at the limits of human perception. Like sound waves, seismic primary waves (P-waves) are compressional vibrations, with frequencies ranging from 0.01 Hz up to around 100 Hz.

This low end of the frequency spectrum offers intriguing possibilities for listening to the earth. Frequencies below 20 Hz, generally regarded as the lower limit of human auditory perception, are known as infrasound. They are felt by humans rather than heard, and sensed – if they are sensed at all – 'as pulses or tactile pressure' (Ganchrow, 2015: 182). Infrasound can move over great distances. The science of infrasonics had its inception following the eruption of Krakatoa in 1883, when waves of changes in barometric pressure were observed circling around the world several times (Evers and Haak, 2010). Animals such as whales, elephants and rhinoceroses are believed to use infrasound for long-distance communication (Payne et al., 1986; Langbauer et al., 1991; von Muggenthaler et al., 2003). Expanding listening to acknowledge these long wavelengths provokes a rethinking of scale and the geographies of media. Infrasonic vibrations connect bodies across planetary distances, with the oceans, earth and atmosphere transmitting signals in ways that vastly predate the human inventions of radio, telegraphy and the internet. Geotechnological listening enables us to hear what Kahn (2013) calls the natural history of media.

Many infrasound phenomena are only detectable on human registers with specialized listening technologies. Again, Cold War geopolitics helped to drive the expansion of these systems, because atmospheric nuclear detonations produce infrasound that spreads across large areas, so low frequency detection arrays were developed for monitoring testing activities. A worldwide network of 60 infrasound stations, known as the International Monitoring System (IMS), is now used to enforce the Comprehensive Nuclear-Test-Ban Treaty, together with seismic, hydroacoustic and radionuclide monitoring networks. As well as this global surveillance function, the infrasound arrays pick up signals from a host of earth processes: stratospheric variations in wind and temperature, ocean storms, lightning, tornados, auroras, avalanches, icebergs calving, volcanic eruptions, meteors and other large explosions, even the earth's rotation (Evers and Haak, 2001; Assink et al., 2008; Ottemoller

and Evers, 2008; Evers and Siegmund, 2009; Matoza et al., 2011; Hedlin et al., 2012). Ganchrow (2015: 182–4) points out that:

> the frequency band the human organism is orientated towards is roughly at a scale that interacts with small- to medium-sized objects in our environment. In contrast, the scale of infrasound interacts with the scale of topography or even of the atmosphere itself ... it literally connects the solid earth to oceans and weather, as well as to modern industrial practices.

Infrasound monitoring is thus a form of expanded listening, centred not on human perception but on how materials are perturbed by certain frequencies. Unlike with the forms of listening we have discussed in relation to landscape, and the forms of bodily response produced by sound as affect, in many cases the human body plays no part at all in responding to infrasound. Algorithmic calculations and graphic representations are used to translate the vibrations into comprehensible information. Likewise with seismic monitoring, human auditory perception is either absent or at most is grafted on afterwards through technical means. Time compression has been used to shift the frequency of seismic recordings up into the range of human hearing, reducing their long durations to a more comprehensible timescale, as with the sonification of the Tohoku earthquake (Sendai Coast, Japan, http://youtu.be/3PJxUPvz9Oo; see Peng et al., 2012). This technological accommodation of earthquake vibrations to human perception points to the plasticity of both senses and data (Sterne and Akiyama, 2012). Sound spills across into other sensory registers, through visual representations such as spectrograms and noise maps. Equally, sonic renditions can be produced from any and every kind of geographic information; this is something that deserves much fuller exploration as a geographic method (see Evans and Jones, 2008).

The varied soundings of biotic life have formed new assemblages with technologies. Wildlife sound recording, the science of bioacoustics and the acoustic ecology movement all use listening technologies for sound capture, preservation, archiving, and activism (Gallagher, 2015b). As well as recording the sounds of the more-than-human world, machines act to shape that world, as evident in concerns over noise in animal habitats, such as the effects on aquatic life of vibrations from offshore wind turbines, industrial shipping and military exercises (e.g. Foley, 2014). Audio technologies can also be used to intervene deliberately in inter-species interactions. Composer David Dunn, for instance, has been waging sonic warfare by playing recordings of bark beetles back to the beetles themselves to disrupt their life cycles and limit their effects on forests in North America (Bram, 2013). Audio thus provides a means of reconfiguring the relations between humans, animals and materials.

All of these examples underline our argument that listening is not restricted to the human perception of sounds, but includes the responsiveness of many different bodies and materials to vibrations. Earth sounds, and the technologies that transduce them, situate the human subject as a relatively marginal element amongst many resounding bodies, contributing to a more disparate, relational understanding of the world. Geotechnological listening offers novel ways to investigate the relations between animals, environments, materials, and machines. At the same time, it has the potential to work in exactly the opposite direction, forcing an awareness of how narrowly we humans perceive sound, how much of it passes us by, and how indifferent it can be to our concerns. That awareness brings a humility about our ability to know the world, and about our place within it – a humility that is particularly valuable in an age of ecological crisis (Kanngieser, 2015).

VI Conclusion

In this paper we have argued for the importance of expanding listening in geography. While

numerous studies on specific forms of sound have been undertaken within the discipline, little has been done to clearly engage the broader question of what geography as a whole might gain from a deeper engagement with listening. Our aim has been to articulate how listening can contribute to nuanced and less essentialized understandings of the world, recognizing its polyphonic complexity and simultaneity. In doing so, we have shown that a wider conception of geographic listening can both enlarge what we understand by human subjectivity and also make space for other kinds of audio receptivity. Bringing together the use of sound in diverse geo-spatial practices – mapping landscapes, charting animal populations, understanding social configurations, investigating technologies of warfare and governance, monitoring earthquakes – this paper has outlined how expanded listening can be used to research spaces, places, and environments.

In inviting a different kind of listening, the paper has undertaken three tasks. The first has been to survey current debates on sound, listening, and space, both from within and outside the geographical literature. The second task has been to propose an expanded concept of listening, to deepen, and extend beyond, humanistic perspectives. Given the urgency of global environmental change, the move to foreground the planetary subject has never been more pressing. To demonstrate how listening might be deployed in geography, across human and more-than-human realms, our third task has been to outline some of the specific contributions that expanded listening can make to three thematic trajectories within contemporary geography in which an interest in sound is already evident: landscape, affect, and geotechnologies. These three themes have enabled us to narrate the expansion of listening we have in mind: from that which is tethered to human cochlear listening, moving outward through sound as affects and atmospheres, to the responsiveness of more-than-human technologies, materials and species to sound.

These discussions have created space to think about how sonic geographies may sit – or not – alongside the various conceptual devices geographers use in the study of terrains, atmospheres, and environments. Put another way, we wanted to ask (and to continue asking): how does listening shape our experience and knowledge of landscapes? How can the generation, movement and impact of affective atmospheres be understood through the vibrations of human and more-than-human bodies and environments? And how does sound and listening help us to develop less human-centric perspectives more generally? Through posing such questions, listening and sonic experience present challenging points of departure, requiring the reconfiguration of conventions in formulating, undertaking, and communicating the results of geographical research.

Audio Files Appendix

audio file: birds-in-meadow.mp3

An ambient stereo recording consisting predominantly of the sounds of birds and insects sounding across a grassland meadow located adjacent to a wheat field, Spišská Belá, Slovakia. Recorded 26 July 2013.

audio file: oystercatchers.mp3

An ambient stereo recording of oystercatcher vocalizations reverberating off of a rocky beach and hard cliff sides located on the south of the Isle of Mull, Scotland. Recorded 10 June 2013.

audio file: bridge-contact-microphone.mp3

A mono contact microphone recording of sounds vibrating internally within a concrete and metal road/pedestrian bridge spanning the Danube River, Bratislava, Slovakia. The contact microphone was attached directly between two sheets of metal on the pedestrian path of the bridge. Predominant sounds include the rumble of vehicular traffic, pedestrians talking, and the

bridge itself shaking. Recorded 5 September 2011.

audio file: overhead-power.mp3

An ambient stereo recording of electricity running through an overhead power line, recorded in an agricultural field in Balerno, Scotland. Recorded 29 September 2013.

audio file: leaves-branches.mp3

The sounds of leaves and branches make for distinctive atmospheres, evident in this stereo recording of strong wind moving deciduous trees in leaf next to an urban cycle path in Edinburgh. Recorded 1 June 2011.

audio file: boat-harbour.mp3

An ambient stereo recording of the atmosphere of Dunbar Harbour in summertime, including the sound of a boat engine idling and the cries of kittiwakes and other seabirds. Recorded 13 July 2012.

audio file: lrad.mp3

The sound of a Long Range Acoustic Device replicated through a tone generator and digital audio processing.

audio file: reverberant-absorbent.mp3

Contrasting ambient stereo recordings of (i) voices reverberating in a stone stairwell in the Pałac Kultury i Nauki, Warsaw (recorded 19 June 2009), and (ii) voices absorbed by the cork-lined Serpentine Pavilion, London, by Herzog and De Meuron and Ai Weiwei (recorded 21 June 2012).

audio file: automated-announcements.mp3

A stereo recording of automated announcements in Edinburgh Waverley railway station. Recorded 5 August 2014.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work was supported by a British Academy/Leverhulme Small Research Grant (Grant Number SG132143).

References

Adams M (2009) Hearing the city: Reflections on soundwalking. *Qualitative Researcher* 10: 6–9.

Adams M, Cox T, Moore G, Croxford B, Refaee M and Sharples S (2006) Sustainable soundscapes: Noise policy and the urban experience. *Urban Studies* 4(13): 2385–2398.

Adey P, Brayer L, Masson D, Murphy P, Simpson P and Tixier N (2013) Pour votre tranquillité': Ambiance, atmosphere, and surveillance. *Geoforum* 49: 299–309.

Anderson B (2004) Recorded music and practices of remembering. *Social and Cultural Geography* 5: 3–20.

Anderson B (2009) Affective atmospheres. *Emotion, Space and Society* 2: 77–81.

Anderson B and Ash J (2014) Atmospheric methods. In: Vannini P (ed.) *Nonrepresentational Methods: Re-envisioning Research*. London: Routledge.

Ash J (2013) Rethinking affective atmospheres: Technology, perturbation and space times of the non-human. *Geoforum* 49: 20–28.

Ash J (2015) Technology and affect: Towards a theory of inorganically organised objects. *Emotion, Space and Society* 14: 84–90.

Assink JD, Evers LG, Holleman I and Paulssen H (2008) Characterization of infrasound from lightning. *Geophysical Research Letters* 35.

Atkinson R (2007) Ecology of sound: The sonic order of urban space. *Urban Studies* 44: 1905–1917.

Atkinson R (2011) Ears have walls: Thoughts on the listening body in urban space. *Aether: The Journal of Media Geography* 7: 12–26.

Augoyard JF and Torgue H (2008) *Sonic Experience: A Guide to Everyday Sounds*. Montreal: McGill-Queen's University Press.

Back L (2007) *The Art of Listening*. Oxford: Berg.

Benediktsson K (2007) 'Scenophobia', geography and the aesthetic politics of landscape. *Geografiska Annaler, Series B: Human Geography* 89(3): 203–217.

Bennett K, Cochrane A, Mohan G and Neal S (2015) Listening. *Emotion, Space and Society* 17: 7–14.

Berleant A (1992) *The Aesthetics of Environment*. Philadelphia: Temple University Press.

Bissell D (2010) Passenger mobilities: Affective atmospheres and the sociality of public transport. *Environment and Planning D: Society and Space* 28(2): 270–289.

Blesser B and Salter LR (2007) *Spaces Speak, Are You Listening? Experiencing Aural Architecture*. Cambridge, MA: MIT Press.

Born G (2013) *Music, Sound and Space: Transformations of Public and Private Experience*. Cambridge: Cambridge University Press.

Boyd C and Duffy M (2012) Sonic geographies of shifting bodies. *Interference: A Journal of Audio Culture* 1(2): 1–7.

Bourassa SC (1991) *The Aesthetics of Landscape*. London: Belhaven Press.

Bram D (2013) Planet waves. *The Wire* 357: 37–43.

Butler T (2006) A walk of art: The potential of the sound walk as practice in cultural geography. *Social and Cultural Geography* 7: 889–908.

Butler T (2007) Memoryscape: How audio walks can deepen our sense of place by integrating art, oral history and cultural geography. *Geography Compass* 1: 360–372.

Butler T and Miller G (2005) Linked: A landmark in sound, a public walk of art. *Cultural Geographies* 12: 77–88.

Chakraborty B and Fernandes W (2012) Bathymetric techniques and Indian Ocean applications. In: Blondel P (ed.) *Bathymetry and its Applications*. Croatia: InTech Open Access Publisher.

Chion M (1994) *Audio-Vision: Sound on Screen, trans*. Gorbman C. New York: Columbia University Press.

Clark A and Moss P (2011) *Listening to Young Children: The Mosaic Approach*. London: National Children's Bureau.

Cox R (2010) The sound of freedom: US military aircraft noise in Okinawa. *Anthropology News* 51: 13–14.

Cox C (2011) Beyond representation and signification: Toward a sonic materialism. *Journal of Visual Culture* 10(2): 145–161.

Cusick SG (2006) Music as torture/music as weapon. *TRANS-Transcultural Music Review* 10.

Cusick SG (2008) 'You are in a place that is out of the world': Music in the detention camps of the 'global war on terror'. *Journal of the Society for American Music* 2(1): 1–26.

Cusick SG (2013) Acoustemology of detention in the 'global war on terror'. In: Born G (ed.) *Music, Sound and Space: Transformations of Public and Private Experience*. Cambridge: Cambridge University Press, 275–291.

Davies WJ, Adams MD, Bruce NS, Cain R, Carlyle A, Cusack P, Hall DA, Hume KI, Irwin A, Jennings P, Marselle M, Plack CJ and Poxon J (2013) Perception of soundscapes: An interdisciplinary approach. *Applied Acoustics* 74(2): 224–231.

Deleuze G and Guattari F (1988) *A Thousand Plateaus: Capitalism and Schizophrenia*, trans. Massumi B. London: The Althone Press.

Deleuze G and Guattari F (1994) *What Is Philosophy?*, trans. Tomlinson H and Burchell G. New York: Columbia University Press.

Descola P (2013) *The Ecology of Others*, trans. Godbout G and Luley BP. Chicago: Prickly Paradigm Press.

DeSilvey C (2010) Memory in motion: Soundings from Milltown, Montana. *Social and Cultural Geography* 11: 491–510.

Drever JL (1999) The exploitation of 'tangible ghosts': Conjectures on soundscape recording and its reappropriation in sound art. *Organised Sound* 4: 25–29.

Drever JL (2002) Soundscape composition: The convergence of ethnography and acousmatic music. *Organised Sound* 7: 21–27.

Duff C (2010) On the role of affect and practice in the production of place. *Environment and Planning D: Society and Space* 28(5): 881–895.

Duffy M and Waitt G (2013) Home sounds: Experiential practices and performativities of hearing and listening. *Social and Cultural Geography* 14: 466–481.

Ervin S and Steinitz C (2003) Landscape visibility computation: Necessary, but not sufficient. *Environment and Planning B* 30: 757–766.

Evans J and Jones P (2008) Towards Lefebvrian socionature? A film about rhythm, nature and science. *Geography Compass* 2: 659–670.

Evernden N (1981) The ambiguous landscape. *Geographical Review* 71(2): 147–157.

Evers LG and Haak HW (2001) Listening to sounds from an exploding meteor and oceanic waves. *Geophysical Research Letters* 28: 41–44.

Evers LG and Haak HW (2010) The characteristics of infrasound, its propagation, and some early history. In: Le Pichon A, Blanc E and Hauchecorne A (eds) *Infrasound Monitoring for Atmospheric Studies*. New York: Springer, 3–29.

Evers LG and Siegmund P (2009) Infrasonic signature of the 2009 major sudden stratospheric warming. *Geophysical Research Letters* 36.

Faudree P (2012) Music, language, and texts: Sound and semiotic ethnography. *Annual Review of Anthropology* 41: 519–536.

Feigenbaum A and Kanngieser A (2015) For a politics of atmospheric governance. *Dialogues in Human Geography* 5(1): 80–84.

Feld S (1996) Waterfalls of song: An acoustemology of place resounding in Bosavi, Papua New Guinea. In: Feld S and Basso K (eds) *Senses of Place*. Santa Fe: School of American Research Press, 91–135.

Fisher JA (1998) What the hills are alive with: In defense of the sounds of nature. *The Journal of Aesthetics and Art Criticism* 56(2): 167–179.

Foley JA (2014) U.S. Navy sued for violating Marine Mammal Protection Act in connection with sonar training exercises. *Nature World News*. Available at: http://www.natureworldnews.com/articles/5803/20140128/navy-sued-violatingmarine-mammal-protection-act-connection-onar-training.htm (accessed 23 May 2016).

Forsyth I, Lorimer H, Merriman P and Robinson J (2013) What are surfaces? *Environment and Planning A* 45(5): 1013–1020.

Gallagher M (2010) Are schools panoptic? *Surveillance and Society* 7: 262–272.

Gallagher M (2011) Sound, space and power in a primary school. *Social and Cultural Geography* 12: 47–61.

Gallagher M (2013) Listening, meaning and power. In: Carlyle A and Lane C (eds) *On Listening*. Axminster: Uniformbooks, 41–44.

Gallagher M (2014) Urban listening and the production of space: Reflections on Tuned City Brussels. *Tacet* 3: 163–185.

Gallagher M (2015a) Sounding ruins: Reflections on the production of an 'audio drift'. *Cultural Geographies* 22(3): 467–485.

Gallagher M (2015b) Field recording and the sounding of spaces. *Environment and Planning D: Society and Space* 33(3): 560–576.

Gallagher M (2016) Sound as affect: Difference, power and spatiality. *Emotion, Space and Society*. Available at: http://dx.doi.org/10.1016/j.emospa.2016.02.004 (accessed 23 May 2016).

Gallagher M and Prior J (2014) Sonic geographies: Exploring phonographic methods. *Progress in Human Geography* 38(2): 267–284.

Ganchrow R (2015) On long wave synthesis. In: Altena A, Belina M and van der Velden L (eds) *The Geologic Imagination*. Amsterdam: Sonic Acts Press, 179–198.

Goodman S (2009) *Sonic Warfare: Sound, Affect and the Ecology of Fear*. Cambridge, MA: MIT Press.

Gregg M and Seigworth GJ (2010) An inventory of shimmers. In: Gregg M and Seigworth GJ (eds) *The Affect Theory Reader*. Durham: Duke University Press, 1–29.

Handel S (1993) *Listening: An Introduction to the Perception of Auditory Events*. Cambridge, MA: MIT Press.

Haraway D (2003) *The Companion Species Manifesto: Dogs, People and Significant Otherness*. Chicago: Prickly Paradigm Press.

Hedlin MAH, Walker K, Drob DP and de Groot-Hedlin CD (2012) Infrasound: Connecting the solid earth, oceans, and atmosphere. *Annual Review of Earth and Planetary Sciences* 40: 327–354.

Hennix CC (2015) On ritual and omsahatranamam. *Sound American* 11. Available at: http://soundamerican.org/catherine-christer-hennix-on-ritual-and- (accessed 6 June 2015).

Henriques JF (2011) *Sonic Bodies: Reggae Sound Systems, Performance Techniques and Ways of Knowing*. New York: Continuum.

Hill I (2012) Not quite bleeding from the ears: Amplifying sonic torture. *Western Journal of Communication* 76(3): 217–235.

Hodgetts T and Lorimer J (2015) Methodologies for animals' geographies: Cultures, communication and genomics. *Cultural Geographies* 22(2): 285–295.

Ingold T (2000) *The Perception of the Environment: Essays on Livelihood, Dwelling and Skill*. New York: Routledge.

Ingold T (2007) Against soundscape. In: Carlyle A (ed.) *Autumn Leaves: Sound and the Environment in Artistic Practice*. Paris: Double Entendre, 10–13.

Jackson M and Fannin M (2011) Letting geography fall where it may: Aerographies address the elemental. *Environment and Planning D: Society and Space* 29(3): 435–444.

Jones K (2005) Music in factories: A twentieth-century technique for control of the productive self. *Social and Cultural Geography* 6: 723–744.

Kahn D (2013) *Earth Sound Earth Signal: Energies and Earth Magnitude in the Arts*. Berkeley: University of California Press.

Kanngieser A (2012) A sonic geography of the voice: Towards an affective politics. *Progress in Human Geography* 36(3): 336–353.

Kanngieser A (2013) Tracking and tracing: Geographies of logistical governance and labouring bodies. *Environment and Planning D: Society and Space* 31(4): 594–610.

Kanngieser A (2015) Geopolitics and the Anthropocene: Five propositions for sound. *Geohumanities* 1(1): 80–85.

Kanngieser A and Kogawa T (2013) A micro-history of 'convivial' radio in Japan: A conversation with Tetsuo Kogawa with an introduction by Anja Kanngieser. *Parallax* 19: 85–94.

Kim-Cohen S (2009) *In the Blink of an Ear: Toward a Non-Cochlear Sound Art*. New York: Continuum.

Kinsler LE, Frey AR, Coppens AB and Sanders JV (2000) *Fundamentals of Acoustics,4th edn*. New York: John Wiley & Sons.

LaBelle B (2006) *Background Noise: Perspectives on Sound Art*. London: Continuum.

LaBelle B (2010) *Acoustic Territories: Sound Culture and Everyday Life*. London: Continuum.

Langbauer WR, Payne KB, Charif RA, Rapaport L and Osborn F (1991) African elephants respond to distant playbacks of low-frequency conspecific calls. *Journal of Experimental Biology* 157: 35–46.

Lingis A (1998) *The Imperative*. Bloomington: Indiana University Press.

Lorimer H (2007) Songs from before: Shaping the conditions for appreciative listening. In: Gagen E, Lorimer H and Vasudevan A (eds) *Practising the Archive: Reflections on Method and Practice in Historical Geography*. London: Institute of British Geographers, 57–73.

Lorimer H (2013) Scaring crows. *Geographical Review* 103: 177–189.

Lorimer H and Wylie J (2010) LOOP (a geography). *Performance Research* 15: 6–13.

Lowenthal D (2007) Living with and looking at landscape. *Landscape Research* 32(5): 635–656.

Lynch E, Joyce D and Fristrup K (2011) An assessment of noise audibility and sound levels in U.S. *National Parks.* Landscape Ecology 26(9): 1297–1309.

McCormack D (2008) Engineering affective atmospheres on the moving geographies of the 1897 Andree expedition. *Cultural Geographies* 15(4): 413–430.

MacDonald F (2011) Doomsday fieldwork, or, how to rescue Gaelic culture: The salvage paradigm in geography, archaeology, and folklore, 1955–62. *Environment and Planning D: Society and Space* 29: 309–335.

Massumi B (2002) *Parables for the Virtual: Movement, Affect, Sensation*. Durham: Duke University Press.

Matless D (2000) Versions of animal–human: Broadland, c. 1945–1970. In: Philo C and Wilbert C (eds) *Animal Spaces, Beastly Places: New Geographies of Human-Animal Relations*. London: Routledge, 117–141.

Matless D (2005) Sonic geography in a nature region. *Social and Cultural Geography* 6: 745–766.

Matoza RS, Vergoz J, Le Pichon A, Ceranna L, Green DN, Evers LG, Ripepe M, Campus P, Liszka L, Kvaerna T, Kjartansson E and Hoskuldsson A (2011) Long-range acoustic observations of the Eyjafjallajokull eruption, Iceland, April–May 2010. *Geophysical Research Letters* 38.

Merchant ND, Blondel P, Dakin DT and Dorocicz J (2012) Averaging underwater noise levels for environmental assessment of shipping. *Journal of the Acoustical Society of America* 132(4): EL343–EL349.

Miller NP (2008) US National Parks and management of park soundscapes: A review. *Applied Acoustics* 69(2): 77–92.

Montgomery W (2009) Beyond the soundscape: Art and nature in contemporary phonography. In: Saunders J (ed.) *The Ashgate Research Companion to Experimental Music*. Farnham: Ashgate, 145–161.

Montgomery W (2011) Sounding the Heygate Estate. *City* 15: 443–455.

Moorhouse A, Waddington D and Adams M (2011) *Procedure for the Assessment of Low Frequency Noise Complaints*. Manchester: University of Salford.

Motloch JL (2001) *Introduction to Landscape Design, 2nd edn*. New York: John Wiley & Sons.

Nancy JL (2007) *Listening*, trans. Mandell C. New York: Fordham University Press.

O'Callaghan C (2007) *Sounds: A Philosophical Theory*. Oxford: Oxford University Press.

Olwig KR (1996) Recovering the substantive nature of landscape. *Annals of the Association of American Geographers* 86(4): 630–653.

Oosterlynck S and Swyngedouw E (2010) Noise reduction: The postpolitical quandary of night flights at Brussels Airport. *Environment and Planning A* 42: 1577–1594.

Ottemoller L and Evers LG (2008) Seismo-acoustic analysis of the Buncefield oil depot explosion in the UK,

2005 December 11. *Geophysical Journal International* 172: 1123–1134.

Parsons R and Daniel TC (2002) Good looking: In defense of scenic landscape aesthetics. *Landscape and Urban Planning* 60(1): 43–56.

Payne KB, Langbauer WR and Thomas EM (1986) Infrasonic calls of the Asian elephant (Elephas-Maximus). *Behavioral Ecology and Sociobiology* 18: 297–301.

Peng Z, Aiken C, Kilb D, Shelly DR and Enescu B (2012) Listening to the 2011 magnitude 9.0 Tohoku-Oki, Japan, earthquake. *Seismological Research Letters* 83: 287–293.

Pieslak J (2009) *Sound Targets: American Soldiers and Music in the Iraq War*. Bloomington: Indiana University Press.

Pinder D (2001) Ghostly footsteps: Voices, memories and walks in the city. *Ecumene* 8: 1–19.

Power N (2013) Cyborg manifestos. *The Wire* 352: 37.

Prior JD (2012) *The roles of aesthetic value in ecological restoration: Cases from the United Kingdom*. Unpublished PhD thesis, Department of Geography, University of Edinburgh.

Raimbault M and Dubois D (2005) Urban soundscapes: Experiences and knowledge. *Cities* 22(5): 339–350.

Rennie T (2014) Socio-sonic: An ethnographic methodology for electroacoustic composition. *Organised Sound* 19: 117–124.

Revill G (2013) Points of departure: Listening to rhythm in the sonoric spaces of the railway station. In: Smith RJ and Hetherington K (eds) *Urban Rhythms: Mobilities, Space and Interaction in the Contemporary City*. Chichester: Wiley Blackwell/The Sociological Review, 51–68.

Revill G (2014) El tren fantasma: Arcs of sound and the acoustic spaces of landscape. *Transactions of the Institute of British Geographers* 39(3): 333–344.

Revill G (2015) How is space made in sound? Spatial mediation, critical phenomenology and the political agency of sound. *Progress in Human Geography*. DOI: 10.1177/0309132515572271.

Rice T (2013) *Hearing and the Hospital: Sound, Listening, Knowledge and Experience*. Canon Pyon: Sean Kingston Publishing.

Scazzosi L (2004) Reading and assessing the landscape as cultural and historical heritage *Landscape Research* 29(4): 335–355.

Schafer RM (1977) *The Tuning of the World*. New York: Knopf.

Schafer RM (1985) Acoustic space. In: Seamon D and Mugerauer R (eds) *Dwelling, Place and Environment: Towards a Phenomenology of Person and World*. Dordrecht: Nijhoff, 87–98.

Scrimshaw W (2013) Non-cochlear sound: On affect and exteriority. In: Thompson M and Biddle I (eds) *Sound, Music, Affect: Theorizing Sonic Experience*. New York: Bloomsbury Academic, 27–43.

Sheller M (2004) Mobile publics: Beyond the network perspective. *Environment and Planning D: Society and Space* 22: 39–52.

Simpson P (2009) 'Falling on deaf ears': A postphenomenology of sonorous presence. *Environment and Planning A* 41: 2556–2575.

Smardon RC, Palmer JF and Felleman JP (1986) *Foundations for Visual Project Analysis*. New York: John Wiley & Sons.

Sterne J and Akiyama M (2012) The recording that never wanted to be heard and other stories of sonification. In: Pinch T and Bijsterveld K (eds) *The Oxford Handbook of Sound Studies*. New York: Oxford University Press, 544–560.

Tegowski J, Deane G, Lisimenka A and Blondel P (2011) Underwater ambient noise of glaciers on Svalbard as indicator of dynamic processes in the Arctic. *Proceedings of the Institute of Acoustics* 33: 83–85.

Truax B (1984) *Acoustic Communication*. Norwood: Ablex Publishing,

Vaisman D (2002) The acoustics of war. *Cabinet* 5. Available at: http://cabinetmagazine.org/issues/5/acousticsofwar.php (accessed 10 July 2014).

Von Muggenthaler E, Reinhart P, Lympany B and Craft RB (2003) Songlike vocalizations from the Sumatran Rhinoceros (*Dicerorhinus sumatrensis*). *Acoustics Research Letters Online* 4: 83–88.

Waitt G and Duffy M (2010) Listening and tourism studies. *Annals of Tourism Research* 37: 457–477.

Waitt G, Harada T and Duffy M (2015) 'Let's have some music': Sound, gender and car mobility. *Mobilities*. DOI: 10.1080/17450101.2015.1076628.

Waitt G, Ryan E and Farbotko C (2014) A visceral politics of sound. *Antipode* 46: 283–300.

Whatmore S (2002) *Hybrid Geographies: Natures, Cultures, Spaces*. London: SAGE.

Wolman D (2002) Calls from the deep. *New Scientist* 2347: 35.

Wylie JW (2007) *Landscape*. London, Routledge.

Author biographies

Michael Gallagher is a research fellow in the Faculty of Education at Manchester Metropolitan University. His interests include sound and space, children and young people, power, media and research methods. His work often involves experimentation with audio and other kinds of electronic media. http://www.michaelgallagher.co.uk

Anja Kanngieser is vice chancellor's post-doctoral fellow at the Australian Centre for Cultural Environmental Research, University of Wollongong, with a background in geography and communication studies. Her work focuses on the intersections of political economy and ecology, sound and social movements. She is primarily interested in the ways in which people strategise, antagonise and collaborate to create the living and working conditions they desire. Bringing into dialogue political economic theory with audio practices, she is engaged in the experimentation and invention of sound based methods in the social sciences. http://anjakanngieser.com/

Jonathan Prior is a lecturer in human geography in the School of Geography and Planning at Cardiff University. His research interests span environmental and landscape policy – in particular, the role of environmental aesthetic values within policy making – and sonic geography. Within the latter area, he is working on ways in which researchers can more fully attend to the sonic qualities of landscapes. http://12gatestothecity.com/