Engaging Science, Technology, and Society

THEMATIC COLLECTION: SITUATING MICROBES ORIGINAL RESEARCH ARTICLE

Geographies of Tolerance: Hiding the Lyme Disease Epidemic in Scotland's Landscapes

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Abstract

Little research has been conducted on the relationship between Lyme disease and the landscapes in which people became infected. This article remedies this gap by researching the interplay of environment, ticks, bacteria, and humans. Based on fieldwork across Scotland in 2018–2020, this article explores the tension of Scottish landscapes as both beautiful and as having the highest incidence of Lyme disease in Europe. I introduce the people living with chronic Lyme disease and the epidemiologists and entomologists researching Lyme disease in Scotland, and explore their relationships to the landscapes of the bacteria. Introducing the theoretical framework 'geographies of tolerance', I explore how Scottish landscapes are constructed as safe and healthy: an exploration of how spaces are constructed around ideas of safety, and how this safety is extended to the animals, microbes, and diseases found within those spaces. Perceived as fundamentally safe, any potential dangers encountered in spaces are thereby tolerated and the possibility of danger becomes invisible. Finally, I apply geographies of tolerance to make sense of Britain's response to the Covid-19 pandemic and the impact that lockdown had on rendering *B. burgdorferi* more tolerable and more invisible.

Keywords

Lyme disease; Lyme wars; chronic illness; landscape; Scotland; NHS; Covid-19; ticks

To cite this article Soncco, Ritti. 2025. "Geographies Of Tolerance: Hiding the Lyme Disease Epidemic in Scotland's Landscapes." *Engaging Science, Technology, and Society* 11(1): 101–124. https://doi.org/10.17351/ests2023.1611.

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Introduction

Figure 1. Camping in Glen Coe, Scotland. Photograph taken by Benedictine Khor and the author, July 2020.

Imagine you're standing in the Scottish Highlands, watching clouds fleet across the sky changing the mood of the mountains. The silence in the crisp air around you is punctuated by the low haunting of deer rutting. Scotland's landscapes invite stillness and immersion: wild camping on mountains to watch the sun set (figure 1), awe at the Milky Way, hope for a cloud inversion in the morning. Countless authors have attempted to capture in words what these sublime landscapes mean to them – but these Scottish spaces also carry the highest incidence of the Lyme disease epidemic in Europe (Ling et al. 2000).

This tension between the beauty of the landscapes and their diseases are at the heart of this article. How can we understand beautiful spaces that are historically romanticized and welcoming to people, and that at the same time require caution because they harbor a serious disease? To explore this tension, I introduce the framework of 'geographies of tolerance': an exploration of how spaces are constructed around ideas of safety, and how this safety is extended to the animals, bacteria, and diseases found within those spaces. This is important because while much has been written about Lyme disease, there is little discussion on the relationship between the illness and the spaces in which people became infected.

This article begins with an introduction to Lyme disease, the Lyme wars, and the literature on chronic Lyme disease to date. Building on 15 months of ethnographic data collection over the years 2018–2020, this article follows the human-bacteria relationships in Scotland: I introduce the people living with chronic Lyme disease and the epidemiologists and entomologists researching Lyme disease in Scotland, and explore their relationships to the landscapes they situate the bacteria in. Turning to Scotland's construction of landscapes as safe spaces for hillwalking, I expand upon the concept 'geographies of tolerance' to explore how historical human-landscape relationships render (Koch 2011) the bacteria into 'safe' and 'tolerable'. I then turn to explore how Scottish landscapes are constructed as safe and healthy, doing so through the lens of my theoretical framework 'geographies of tolerance'. Finally, I apply geographies of tolerance to make sense of Britain's slow reaction to the Covid-19 pandemic and the impact that lockdown has on rendering the bacteria more safe, more tolerable, and even invisible.

The Lyme Disease Epidemic

Lyme disease is a complex multi-organ illness caused by the bacteria *Borrelia burgdorferi* and spread in Scotland by the tick vector *Ixodes ricinus*. Lyme disease can manifest itself in diverse ways: the most common is the *erythema migrans* or bull's eye rash; and as the bacteria enters the bloodstream, various organ systems become affected: the heart, causing Lyme carditis and further cardiac manifestations (Silver 2017); the nervous system, causing cognitive and neurological problems (LymeDiseaseUK 2025); and the joints, causing inflammatory arthritis (Dattwyler and Sperber 2011). Affecting such a diversity of organs results in a myriad of symptoms that range from skin rashes, photosensitivity, swollen joints, headaches and fatigue to 'endocrine and neurological systems and experience musculoskeletal, cardiac, dermatological and neuropsychiatric problems' (LymeDiseaseUK 2022). Due to the bacteria's complexity of symptoms, Lyme disease is commonly misdiagnosed as: 'ME/chronic fatigue syndrome, fibromyalgia, multiple sclerosis, dementia, depression, and anxiety disorders' (LymeDiseaseUK 2025). Following the medical guidelines set out by the National Institute for Health and Care Excellence (NICE), Lyme disease is treated with a 21-day course of antibiotics after which the person is said to be cured.

Unfortunately, Lyme disease is at the center of international dispute concerning its medical knowledge. To facilitate the conversation, we will call one discourse 'evidence-based' and the other 'Lyme-literate' – however, it is important to note that Lyme-literate medicine is equally biomedical and evidence-based. I call the first camp 'evidence-based' for several reasons: first, to adhere to hitherto published literature and how other medical anthropologists name and differentiate the two; second, to differentiate it from Lyme-literate medicine. The biomedical side is represented by the Infectious Diseases Society of America (IDSA) and argues that the diagnostic tools suffice to pick up infection; that *Borrelia* can be flushed out of the body with 21 days of antibiotics; and that it cannot persist this treatment, i.e., Lyme disease cannot become chronic. The Lyme-literate side is represented by the International Lyme and Associated Diseases Society (ILADS) and argues that the diagnostic tools do not always pick up infection; that multiple months of multiple different antibiotics may be needed to flush the bacteria out of the body; and that *Borrelia* can persist and Lyme disease can become chronic. The tension between these two knowledge discourses is known internationally as 'the Lyme wars' in which evidence-based clinicians have called chronic Lyme patients 'well-intentioned and misinformed' (Halperin et al. 2011, 259) at best and 'Lyme loonies' (Pfeiffer 2018, 81) at worst, and have accused Lyme-literate doctors of 'trading on frustration and anger, plying fear of the unknown and paranoia to exploit their point of view' (Auwaerter and Melia 2012, 84). Meanwhile, the Lyme-literate community has disparaged evidence-based clinicians as controlling research so they could 'accept consulting fees from insurance companies unwilling to pay out for long term treatments' (Tonks 2007, 911). Writing in *The BMJ*, associate editor Alison Tonks observed: 'This is no longer a disease but a legal and political battleground' (ibid., 910). In Scotland, the Lyme wars are visible in the anger and frustration expressed within patient support groups who consider themselves betrayed by evidence-based doctors: in our interviews, patients called these doctors 'narrow-minded', 'ignorant', and 'criminals' for withholding access to medication and blamed them for patients' deteriorating health. However, while the Lyme Wars draw clear differences in the two forms of medical knowledge production and create real opposition, I argue elsewhere (Soncco 2022) that a binary simplification of these two camps as homogenous and oppositional does not reveal the whole truth: instead, I also found important collaborations across the two sides as well as heterogeneity within seemingly homogeneous groups.

Lyme disease and its contested chronic form have been written about in medical journalism, autobiographical content, medical anthropology, and ecology. The key discussions in medical journalism (Edlow 2003; Pfeiffer 2018; Newby 2019; Weintraub 2013) center patient experiences and socially render (Koch 2011) what it means to live with a contested, chronic illness. Of these, two were of particular interest to my work. In *Lyme: The First Epidemic of Climate Change* (2018), Mary Beth Pfeiffer focuses on the doctor-patient hierarchy, the effectiveness of the diagnostic tests, and Lyme-related deaths and suicides. Kris Newby's book *Bitten: The Secret History of Lyme Disease and Biological Weapons* (2019), explores a theory first popularized in Michael C. Carroll's book *Lab 257: The Disturbing Story of the Government's Secret Germ Laboratory* (2005): that Lyme disease was developed as a biological weapon and the people suffering are entitled to governmental compensation. This popular theory has gained momentum over the years to the point that in 2020, the US House of Representatives ordered the Pentagon to conduct a review on whether experiments had been conducted on ticks as biological weapons in the years 1950–1975.

There is extensive autobiographical content on the internet, ranging from blogs, music albums, YouTube series, to books. The literature that was the most helpful to my research was *Finding Joy* (2017) by Scottish author and patient-advocate Morven-May MacCallum. Her book is a semi-autobiographical novel describing her protagonist's deteriorating health and years of misdiagnosis by the NHS Scotland system. The book's success catapulted MacCallum into advocacy work, making her one of the most important advocates in the country, and brought visibility to an otherwise invisible community.

Where historically-dominant literature on human-microbe relationship discusses it as militaristic (Haraway 1991; Martin 1994; Walker 2020), my article builds on the literature of human-microbe relationship as co-existence (Brives et al. 2021; Haraway 2016; Kirksey 2014; Lorimer 2017), making however two new contributions: first, the role landscapes play in rendering human-microbe relationships of co-existence as safe, regardless of that bacteria's actual safety to human health; and second, how the impact these constructions of safety have on disease communication and risk prevention. To do so, this article builds on two important monographs. The first, *Inescapable Ecologies* (2007) by Linda Nash, focused on California's landscapes during the eras of colonialism, frontierism, the Gold Rush, and the World Wars which was helpful in thinking through how Scottish landscapes could be historically constructed as intrinsically safe in comparison, and the role this constructed safety is playing in making the link between environment, health and people invisible in Scotland today. The second is *Divided Bodies: Lyme Disease, Contested Illness, and Evidence-Based Medicine* (2020) by Abigail A. Dumes. Her book analyses the tension of evidence-based medicine and knowledge production in Lyme disease through the lens of biopower, biopolitics, and biolegitimacy. As Lyme disease is primarily associated with the United States, the magnitude of Dumes' research has been necessary for a long time and was an immensely helpful building block for my own work. Building on Dumes' own work on landscapes, which describes their 'health benefits' (ibid., 74) and 'personal and cultural benefit' (ibid., 75), my article discusses how the landscape construction of safety has extended to a construction of Lyme disease as safe, and how this challenges disease prevention and risk communication in Scotland. Here I make an important distinction: this article is not about the perspective of landscapes as 'healthy' or 'not healthy', but rather as 'not dangerous and not fatal' and thereby 'tolerable' and 'safe'. This discussion of safety builds on Sarah Vogel's work on safety in chemical production, which shows that defining 'safe' is messy, complex, and constantly negotiated and re-interpreted along lines of

economy, 'power, ideology, and values' (2013, 218). Her question of 'What do we mean by *safe*?' (ibid.) echoes throughout this article without a clear answer.

Writing from an ecological perspective, Richard S. Ostfeld's (2011) states that the answers ecology has provided for Lyme disease have so far been incomplete: ecology has left out research on how 'the interactions among organisms determine disease risk' (ibid., 186). This is what Steve Hinchliffe et al. call for in their article *Biosecurity and the Topologies of Infected Life: from Borderlines to Borderlands* (2013): research on the intra-action of the bacteria, how they move, mutate and even network in an 'entangled interplay of environment, hosts, pathogens and humans' (ibid., 532) that 'makes life more or less safe' (ibid., 540). In Scotland, for example, Lyme disease is reported among people with a passion for hillwalking, gardening, and Scottish orienteering and in her doctoral thesis, *Predicting Tick-borne Disease Risk: Improving the Distribution Mapping of Ticks and Tick Bite Risks in Scotland*, Rita Ribeiro was the first to use orienteering to improve predictive maps of ticks and tick bite risk (2021). As we see, the Lyme literature is comparatively sparse when it comes to landscape-human-bacteria intra-actions and this article tackles this important area.

From 2018–2020, I conducted multi-sited fieldwork with 40 people throughout Scotland: Lyme patients, patient advocates, hillwalking groups, doctors, epidemiologists, entomologists, and clinical researchers. Data collection for this research began with participant observation and structured and semi-structured interviews with the Edinburgh University Hillwalking Club (EUHWC), whom I accompanied on various hikes around the Isle of Arran in late May 2018, followed by multi-sited fieldwork at the Blackwater Hostel and Campsite and West Highland Lodge in the village of Kinlochleven to meet people walking the West Highland Way and the Kinlochleven Walks from late May to early June 2018. From September 2019 to September 2020, I interviewed members of 'Lymediseasealba', Scotland's patient support group for people living with Lyme disease and other tick-borne diseases, and attended their meetings which took place in Edinburgh, Glasgow, and online during the Covid-19 pandemic. During this time, I also conducted structured interviews and participant observation at Scotland's Rural College (Inverness) and followed an epidemiologist conducting blanket drags to collect ticks. Further research was conducted at the Scottish Health Protection Network (SHPN), Tick-Borne Diseases Subgroup within the Gastrointestinal Infection and Zoonoses Group of NHS Scotland (SHPN-GIZ) in Glasgow and with the Access, Health and Recreation Advisor for Forestry and Land Scotland.

Every interview I conducted with Lyme patients in Scotland began with their debut stories (Hydén and Sachs 1998), i.e., how and when patients felt the first symptoms of infection. In their debut stories, landscapes were the place where health became illness, but after speaking about their infection, landscapes disappeared from patient stories. Mirroring the dominant narrative in Lyme literature, patients instead centered on medical knowledge production, the Lyme wars, and their frustration with medical institutions. I have focused elsewhere on this dominant narrative (Soncco 2020), so I instead question what dominance makes invisible. I base this argument on two statements: first, Nash's argument that: 'to tell the history of health without reference to specific landscapes is to assume at the outset that landscapes do not matter. . . . Yet even today we recognize that the history of health and disease is not fully divorced from place' (2007, 9); and second, when I asked Lyme patients directly about their relationships with landscapes, they offered important contributions to the missing knowledge lamented by Ostfeld.

Importantly, most Lyme patients can pinpoint precise locations as to where in Scotland they were bitten by a tick.[1] Three anonymous patients wrote:

> My sister was bitten by a tick in September '18 whilst on holiday in Achmelvich, West Coast Scotland
>
> (My) family member noticed a rash [. . .] while volunteering as a Race Marshall in Stirling
>
> I was bitten on the Isle of Rum.

This reveals that patients have a strong memory of the landscapes in which they became infected and a perspective of Scottish landscapes as riddled with tick-borne diseases. I also spoke to the online 'Lymediseasealba' (written the way the patient group refers to themselves) patient support group, asking for comments, thoughts and feedback on the topic. What quickly became obvious was a complicated relationship to the Scottish landscapes that isn't commonly included in Lyme disease discourse. I therefore begin with a comparative analysis of how Lyme researchers are assessing the burden of infected ticks across Scotland and how Lyme patients perceive these sites of infections.

Infection

In the winter of 2019, I was on the campus of Scotland's Rural College (SRUC) on the outskirts of the City of Inverness, speaking to epidemiologist Dr Rita Ribeiro on her research on ticks and Lyme disease in Scotland. Ribeiro's focus was analyzing what methods could improve the reliability of the existing epidemiological maps that predicted tick-borne disease risks. One such predictive map, created by Sen Li et al. in 2016 (Li et al. 2016), had been republished in *The Spectator* under the title 'Map reveals where in Scotland Lyme-infected ticks are most likely to get you' (Cooke 2016). In their conclusions on the study, the team wrote: 'Climate warming was predicted to contribute to a greater frequency of tick–host contact and, therefore, greater chance for pathogen transmission' (Li et al. 2016, 6). The team found that if temperatures rose by 1°C, 'the density of infected ticks would double' (ibid.) and if temperatures rose by 3°C, the density of infected ticks would 'become 11 times greater than current levels' (Cooke 2016). The summer of 2018 was in fact the 'hottest June day for over 40 years' (Siddique and Taylor 2017), creating ideal temperatures for 'bloodsucking horseflies, which are now at levels commonly found in Mediterranean countries' (Doward 2018), and Scotland's 'hottest ever temperature' (BBC 2018). This legacy would later be surpassed by the summer 2020.

However, in their conclusion on tick prevalence in Scotland, Li at al. write, 'A high 'hazard' does not always indicate a high human infection rate. Social factors shaping the pattern of land used for human outdoor activities, such as walking, forest ranging, hunting, hiking, scouting, orienteering and gardening, are likely to highly influence the disease pattern' (2016, 7). Ribeiro's work focused on examining if these social factors could be used to improve scientific mapping practices and better understand actual tick

[1] Some patients were infected while traveling abroad, e.g., Europe or the United States.

distribution. To do so, she compared three methods of data collection: field surveys in the form of blanket drags, citizen science, and the production of LymeApp.

Her first method was blanket dragging (figure 2 and figure 3), a common entomological method for collecting ticks. A one-square-meter white cloth is mounted onto a pole with a rope. The researcher drags the cloth behind them for a few meters, then turns the cloth over to collect the ticks that have attached to the cloth (figure 4). For her data collection, she had chosen two areas—one in the Cairngorms and one in Lochaber—each with 18 sites of different vegetation cover, which she visited from March to November 2019.

Figure 2. Accompanying Ribeiro on one of her final blanket drags outside Inverness in November 2019. Photograph by the author.

Figure 3. Accompanying Ribeiro on one of her final blanket drags outside Inverness in November 2019. Photograph by the author.

Ribeiro told me;

> In one day, I collected 604 ticks in one site, within 250 meters, [. . .] I now have 9,400 ticks in the freezer, and this is excluding larvae. I keep them at -80°C.

Despite this low temperature, she wasn't entirely sure they were dead. She explained;

> Ticks practice hyper parasitism [. . .] So, if they are all together in a pot, the bigger ones will try to take the blood of the other ones. They are quite resistant.

Her second method for data collection was citizen science, i.e., asking volunteers to inform her each time they spent time in the landscapes and came back with ticks.

> I have tick reports from all over Scotland [. . .] I also have reports from the islands, such as the Isle of Skye and the Outer Hebrides, and I have reports from the south of Scotland.

In terms of volunteers, Ribeiro explained she had the most success engaging people who did orienteering, a sport centered around navigating landscapes by compass and running to various checkpoints pinpointed on

an orienteering map. In Scotland, this popular sport moves participants through forests, fields, and hills, and due to their frequent exposure, orienteerers are often knowledgeable about ticks, and can correctly identify them and check for them after each outing. In fact, orienteering is considered a high-risk activity for tick-borne illnesses, alongside 'gardening, hiking, yard work, mowing, walking with or without pets, forestry work, hunting and military activities' (Ribeiro 2021, 103).

Ribeiro explained how she validated the data contributed by orienteerers: with the day of sampling chosen to ensure that the weather conditions were as close as possible to the event day' (Ribeiro 2021, 110), she conducted 75 blanket drags in the event area. 'Then on the event day', she told me, 'I asked people to report ticks'. She did this by setting up a 'tick tent' with a private cubicle, mirror and lights so participants could check themselves for ticks. They reported their findings either on a tablet or by visiting a website. 'I then compare what people reported in terms of ticks and tick bites with what I collected from the vegetation', she told me. In the 11 orienteering events included in her research, '113 (33.2%) reported at least one tick bite and 162 (47.6%) reported at least one tick encounter.[2] In total, 285 tick bites and 595 tick encounters were reported' (ibid., 118). In her blanket drags prior to the event, Ribeiro had collected 2,379 ticks and 'an average of 2.9 ticks were counted per blanket drag' (ibid., 120), the majority of which were 'always collected in a woodland site (45.4% of the 11 events in deciduous woodland, 27.3% in mixed and 27.3% in coniferous woodlands)' (ibid.). In the winter of 2019, Ribeiro was still in the process of analyzing her data but she could already tell me with confidence:

> I found a strong and positive correlation between the average of tick bites reported per person and event, and the average of ticks collected by (blanket) drags in each one of the areas. So, it seems that environmental research and citizen science can help each other.

Her research, which was the first of its kind to document the tick bite rate of orienteering participants, confirmed:

> Human behavior, as the type of activity undertaken, was the factor that most explained human exposure to ticks and tick bites. This study also generated measures of tick bite risk for different outdoor activities, which is important in identifying high risk groups and targeting public health messages (ibid., vii).

[2] Not attached ticks, but ticks found crawling on the body.

Figure 4. Tick picked on during the blanket drag. Ribeiro's hand is shown for scale. Photograph by author.

More research is needed on the correlation between tick bites and infection with Lyme disease to understand how many ticks are carrying *B. burgdorferi*. For this, Ribeiro's final method of data collection could be helpful: her involvement in the large-scale production of LymeApp, a £1.1 million phone application project being co-created by SRUC, NHS Highland, ID MAPS Ltd (International Disease Mapping Apps Limited), the European Space Agency, Avia Gis, and ERGO (Environmental Research Group Oxford Ltd). LymeApp has several goals: first, data collection. Users would be able to upload photos of the tick they found, information on where they were when they picked up the tick, and the temperature and weather in the geographical location at the time. Second, LymeApp will provide citizens with informational maps 'indicating disease risk in (the) user's location and provide medical advice' (ESA Space Solutions 2022). As a surveillance technology, the app could help identify Lyme disease cases that would otherwise be missed. Finally, LymeApp will offer entomologists and epidemiologists reliable data on tick prevalence and areas of infection risk. Using a combination of data provided by satellites (Earth Observation and Global Navigation Satellite Systems), GPS, GPs, and citizens, LymeApp is envisioned to inform and update digital maps in real-time on Scotland's pathogenic landscapes. Ribeiro told me:

> My perception is that people in Scotland are very concerned about ticks. Having information about where ticks are and where *infected* ticks are will be very valuable. Knowing that an area has more prevalence of *Borrelia* than another area . . . People are very, very interested in that. And people love apps.

Ribeiro's words would prove true. The Scottish media excitedly reported on the launch of a demonstration phase of the app[3] in August 2019 and as LymeApp moved into its feasibility study, the Brennan Lab at the MRC-University of the Glasgow Centre for Virus Research announced its own project 'What Makes Viruses Tick' with an incorporated TickMap which aimed to collect tick 'sightings and bitings' (TCV Scotland 2023) around Scotland.[4] Importantly, TickMap was created in partnership with The Conservation Volunteers in Scotland as well as 'LymeDiseaseUK' (written the way the patient group refers to themselves), a patient support group responsible for England that works in close collaboration with Lymesiseasealba; and the Lyme Resource Centre, a charity founded in 2019 and based in Scotland which works in close collaboration with Scottish patient advocates.

Ribeiro's work represents an important change in epidemiological practices. While standing firm in the traditional entomological method of knowledge production through blanket dragging, her work also advocates for two methodological additions: first, the inclusion of citizen science, with Ribeiro using orienteering practise, and second, the inclusion of apps and online tick maps in epidemiological mapping. Her work offers novel practices to map the bacteria accurately and represents a further important aspect: collaboration. As I have demonstrated, the Lyme wars have caused a fraught relationship between many Lyme patients and many Lyme researchers resulting in anger, frustration, and contention – a relationship which is lamented by both sides. The two camps want and need to collaborate with another, and apps and

[3] For the report, please see Eden 2019.

[4] While their primary remit is to collect data from Scotland, the project leaders make clear on the website that submissions from the United Kingdom and the rest of the world are welcome.

online participatory maps signal an important and exciting possibilities for the co-construction of medical knowledge. Moreover, apps and online participatory maps can become a place where Lyme patients can contribute their important knowledge of landscapes while making their personal sites of infection visible to others. Apps like LymeApp and online maps like TickMap have the added importance of updating and communicating risk in real-time, while being easily accessible to the wider public on open-access platforms.[5] In a hopeful article, Campos draws comparisons between Lyme disease and the HIV/AIDS epidemic, stating: 'In the 1980s and '90s a similar community spurred a drive to fund more research. Because of that research, (HIV/AIDS) is no longer a death sentence. . . . I see the 'Lyme wars' as an advance in health care' (Campos 2018). Rather than reproducing the Lyme wars as a bitter tension between two opposing sides, it can be reproduced as a technology of necessary rupture and trouble that advances medicine.

People living with Lyme disease demonstrate a complicated relationship with their landscapes of infection which is best described as a continuum: the landscape slides from spaces of defiance to spaces haunted by anxiety, nightmares, fear, and total avoidance. Writing to me via the 'Lymediseasealba' forum, Joanne (pseudonym) wrote:

> [Being infected] hasn't put me off the countryside at all. I love nature and ticks are not going to prevent me enjoying it.

To Joanne, staying away from the landscapes means giving *B. burgdorferi* yet another victory: the first is over her body, the second over where she goes. Instead, when she enters the landscapes, Joanne is equipped with a new emotional intelligence and tools to ward off sickness:

> I just make sure I take all the precautions I can and would always have a tick kit with me if I was away from home just in case.

To Joanne and other Lyme patients like her, Scottish landscapes are entangled with *B. burgdorferi*, but her illness has provided her with the knowledge and tools to navigate this entanglement.

Janey, however, described the unease and anxiety she feels whenever she visits the site of her infection, Beecraigs Country Park in Linlithgow:

> I feel very creepy and very reticent about going to Beecraigs, and on a couple of occasions when I have been to Beecraigs, the whole thing just feels really creepy. Really, really uncomfortable. I just feel like I should not be there.

Interestingly, Janey's fear is not blanketed across Scotland's landscapes. Instead, it is reserved for her personal site of infection. She told me:

[5] At the time of writing, TickMap was freely accessible, while LymeApp will be sold on app stores.

> Oddly, it doesn't make me feel the same about anywhere else. Even though ticks are ubiquitous, I don't feel the same in (my) garden, I don't feel the same when I've [sic] went for walks in our local woods. It doesn't bother me in the same way. I'm very happy to go elsewhere.

Her fear is echoed by Ribeiro. In our interview, Ribeiro openly discussed her fears of infection and shared the many precautions she took whenever she went out on a blanket drag:

> I am very scared to get Lyme disease. Every time I go to collect ticks, I wear my super layers: tights underneath, trousers on top, then on top of that protective disposable white suits. Wellies. I don't use any other type of shoes. I wear my hair as short as possible and tie it up with a scarf. And then of course I check my body quite often. I don't use gloves because I collect the tick with my fingers. It's impractical to pick them up with tweezers and gloves. So, I use my fingers but I need to be very careful that they don't reach my arms and my hair. It's quite dangerous.

At home, Ribeiro keeps her work clothes separated from her everyday clothes. She made this decision of strict separation after the following incident:

> I found a living tick in my everyday tights. Since then, I am stricter with keeping things separate, and if I can wash the clothes I wore when collecting ticks at 40° or 60°, then I wash them at that temperature. However, sports clothes are expensive so I can wash them only at 30°. Of course, that means I then inspect the clothes very well after they've been washed.

Similar to many Lyme patients, Ribeiro lives near tick hotspots and, being an avid runner and orienteerer, regularly moves through the forests she knows from her research. She told me:

> The best is to go as protected as possible with clothing and then spray yourself with insect repellents. Its efficacy is not 100% scientifically confirmed but I use it. And I always check for ticks.

Finally, other interlocutors described Scottish landscapes as places to be avoided. Anne (pseudonym) told me how she constructed landscapes along emotions of distress, anxiety, and heightened fear. She wrote:

> My terror of ticks extended all the way down to my family and grandchildren where I fretted each time they were outdoors. The terror took over my life, each time I closed my eyes I saw ticks and insects coming for me (and it) gave me frightful reactions of screaming, flailing about flicking off imaginary beasties. It has taken me years to be at peace with nature again.

To Anne, the landscapes are synonymous with the vectors of illness who cross the threshold of Anne's psyche with malicious intent. Unlike Joanne, and Janey, Anne thought of her body-in-landscapes as exposed and without any possibility for protection. The trauma of her illness was furthermore not limited to her own body but extended to the bodies of her family members. To her, Scottish landscapes are constructed as dangerous, vicious spaces against which there is no protection, and only time and conscious work may eventually heal the trauma of infection.

These narratives reveal how the Scottish landscapes are constructed along a continuum of danger: some landscapes are more dangerous than others, some dangers can be protected against better than others. To the people living with Lyme disease, the dangers in the hills cannot be tolerated, nor can Lyme disease be constructed as safe and tolerable. Scottish landscapes are 'tick heaven', as Member of Scottish Parliament

Maree Todd described to the Scottish Parliament in June 2017. This knowledge is common among Lyme patients, Lyme researchers, and residents of rural Scotland.

However, this construction is neither shared nor well-known outside of this demographic. Far from it: Scottish landscapes are internationally known as welcoming and picturesque safe spaces for tourism. The following section explores how Scotland's national past-time, hillwalking, moves along this construction of safety.

Geographies of Tolerance

To understand the social construction of Scottish landscapes, I joined organised groups on excursions on the Isle of Arran in May 2018 and interviewed individual people on the West Highland Way in June 2018. Whenever we discussed the possibility of danger, the people I walked with repeatedly recited a popular British slogan: 'Nothing here can kill you'. Historically, the banner of safety rings true: where 'complicated landscapes could shape disease in unforeseen ways' (Nash 2007, 56), Scottish landscapes seem uncomplicated. There are no volcanoes that release 'invisible gaseous poison' (ibid., 54), no earthquakes that cause abrupt weather changes, and no tropical weather which 'Europeans long associated (with) early death' (ibid., 60). The lynx, brown bear, and wolf that once roamed Scotland are extinct and there are no snakes, with the exception of black adders which can only be found on the Isle of Arran (and I witnessed hillwalking groups using the possibility of seeing snakes as incentive for a walk[6]). This has left Scottish landscapes in a dream-like tension of 'desolate, even haunted' (Machpherson in Hunter [1995] 2014, 108) and 'magic peacefulness' (ibid., 141)—an artificial construction which is ironically 'profoundly a human creation' (Cronon 1996, 7), given that the Highlands were densely populated in the past (Hunter [1995] 2014; Prebble 1963; Richards 2000).

Interestingly, the slogan 'nothing here can kill you' also came as a reply to my questions about tick bites and Lyme disease. Hillwalkers told me of countless tick encounters casually and when I asked Frazer, a young hillwalker, if he had been worried when he was diagnosed with Lyme disease, he revealingly replied: 'Why? It's not like Lyme disease can kill you.' While Lyme disease is not fatal, Pfeiffer (2018) has called for more research on Lyme-related deaths, ranging from heart attacks to suicide. Many other hillwalkers had stories of past infections with *B. burgdorferi* which ranged from comparing it to the common flu or recounting their shock at learning that it could have long-term complications. In 2018, I spoke to immunologist Dr Kate Harrison about the shifting disease patterns and environmental health in Scotland. She recounted:

> What's the worst infectious disease you can have here? The flu, maybe glandular fever if you're unlucky. My grandparents told me stories about how every summer, someone had polio, and they themselves had tuberculosis. But it's been so long since we had an infectious disease that we've forgotten about it. People think we're safe in our bubble.

[6] In fact, the greatest threat to a hillwalker's peaceful wandering is the Highland midge, an insect which does not carry any pathogens but whose presence "just makes you miserable", as a resident of Kinlochleven told me.

This reveals a historic and social construction of safety in both landscapes and microbes: 'nothing here can kill you' applies to both the Scottish landscapes and the diseases they harbor: *B. burgdorferi* is not perceived as dangerous because nothing in Scottish landscapes can kill you. The problem with this perception is that Lyme disease can have very serious long-term health repercussions, frequently leading to becoming house and bed-bound, unable to lead a social life, suicide attempts, and post-traumatic stress disorder from being disbelieved (MacCallum 2017; Pfeiffer 2018; Soncco 2020).

To think through this problem, I offer the concept 'geographies of tolerance' which explores how certain spaces are constructed around ideas of safety, and how this safety is extended to the animals, microbes, and even diseases found within those spaces. Perceived as fundamentally safe, any potential dangers encountered in spaces are then tolerated and the possibility of danger becomes invisible. Therefore, because Scottish landscapes are constructed as safe, a bacteria with potential long-term repercussions such as *Borrelia burgdorferi* is rendered into a safe bacteria. Danger, whether in landscapes or disease, is assigned away from Scotland. In this way, geographies of tolerance speaks to Vogel's work which shows that defining safety is messy, complex, and negotiated by 'implications of power, ideology, and values' (2013, 218). Taking into consideration how serious an illness Lyme disease is, geographies of tolerance echoes Vogel's questions: ''How safe is safe enough?' and 'How certain must we be of the risks?'' (ibid., 3). For people living with Lyme disease, these questions of safety are important as Scottish landscapes cannot be constructed away from the dangers of *B. burgdorferi*. Vogel asks, 'Are the right questions being asked about the risks of human exposure?' (ibid., 13) and Lyme patients and advocates across Scotland answer with a clear, no.

In 2020, the Covid-19 pandemic swept across the United Kingdom and the political response to the pandemic contributed to an additional development of the geographies of tolerance framework. On the 3rd of March 2020, United Kingdom Prime Minister Boris Johnson boasted that he had shaken hands with patients in a Covid-19 ward: 'I shook hands with everybody, you'll be pleased to know. And I continue to shake hands' (Reuters 2020). Two days later, Johnson went on British morning television show 'This Morning' to say: 'For the overwhelming majority of people who get it, this is going to be a mild to moderate illness'. On 27 March 2020, Johnson and several prominent members of his staff[7] tested positive for Covid-19 and far from experiencing the illness as a 'mild to moderate illness', the Prime Minister was placed in intensive care. By the 6th of April 2020, the country was grappling with real anxieties that their Prime Minister could succumb to Covid-19. Following his recovery, Johnson admitted he had been 'in denial' (Kelner 2020) about the severity of the illness.

Despite being one of the first countries in the world to develop a diagnostic test, strategic time was lost in United Kingdom with a slow rollout of tests, a lack of organization around quarantining arrivals and isolating the sick and contact-tracing their friends and family, and the Prime Minister's confusing messaging to the public on the severity of the illness. The country's slow response to the pandemic baffled scientific and medical experts. Editor of *The Lancet*, Dr Richard Horton, said in October 2021:

[7] Health Secretary Matt Hancock and Chief Medical Advisor Chris Whitty also tested positive at this time.

> February was the opportunity for the UK to really prepare, based on testing, isolation, quarantine, physical distancing, ICU capacity and so on. . . . We missed that opportunity. We could have used the month of February, based on what we knew in January (UK Parliament 2021).

Nation-wide enquiries grappled with the question: how could the United Kingdom suffer such a delayed response when they had had the advantage of watching other countries trial different responses and fail? On the 12th of October 2021, the UK Parliament published the report of their independent enquiry, *Coronavirus: Lessons Learnt to Date*, in which Chief Medical Officer for England, Dame Sally Davies said, 'Our infectious disease experts really did not believe that SARS, or another SARS, would get from Asia to us. It is a form of British exceptionalism' (ibid.). Echoing Harrison's comment to me in 2018, Professor Devi Sridhar, Chair of Global Public Health at the University of Edinburgh, cited complacency as one of the key obstacles in the UK's pandemic preparedness:

> There is a sense of complacency because in European countries or in North America we have not seen infectious diseases cause destruction in the way they have been doing on an ongoing basis in poorer countries, who reacted much faster. . . . That is why we got the whole idea and obsession that it was just like a bad flu, whereas in places like west Africa they redeployed their post-Ebola structures towards Covid structures because they knew that an infectious disease can run through society (ibid.).

The report concluded that the UK Covid-19 response was 'one of the worst ever public health failures' (Sample and Walker 2021). However, following my previous analysis of Scotland as a place where 'nothing can kill you', this complacency fits within the pattern of geographies of tolerance: on an island safe of predators, fatal diseases, and complicated landscapes, epidemics and pandemics were imagined as problems of the exotic Other, but never of the United Kingdom. Therefore, diseases that *were* present in the United Kingdom could be tolerated because they could neither be fatal nor hold long-term consequences, i.e., Johnson's initial thoughts of Covid-19 as 'mild to moderate'. By suggesting the British population could develop herd immunity even though other populations such as Italian, French, German and Spanish had not; by keeping schools, businesses and large sporting events open, Johnson was tolerating Covid-19. I therefore argue that 'geographies of tolerance' is a useful framework in order to understand the response to the pandemic in spaces other than Scottish landscape. Unfortunately, the United Kingdom would quickly discover that tolerating Covid-19 had been a mistake. By the 28th of March 2020, the UK would record their highest number of fatalities in a single day—1,019 deaths (Walawalkar 2020)—and by June 2020, the Office for National Statistics reported 180,586 recorded deaths in England and Wales between the 1st of March and the 31st of May 2020 (ONS 2020).

I was mid-way through fieldwork when the Covid-19 pandemic arrived in Scotland and created a new debate on the landscapes: accessibility during lockdown. In Scottish lockdown, people were forbidden from traveling further than 5 miles from their homes, thereby making outdoor green spaces inaccessible to many. For hillwalkers and access campaigners, lockdown and the consequential inaccessibility to Scotland's landscapes was a deeply emotive and contested time, with some citing that the Land Reform (Scotland) Act of 2003 (also known as the Right to Roam) made access to landscapes a human right. One such access campaigner, Nick Kempe, called the inaccessibility to the landscapes a 'restriction of human rights and civil liberties (and an) abuse of legal powers' (Kempe 2020). Writing on the Parks Watch Scotland public website, Kempe argued that even if a hill shared 'a thousand walkers, 10% of them carrying Covid-19

asymptomatically, and there would have still been very little risk of spreading the illness' (ibid.). By asking the population to stay home, so Kempe, the government was creating a further 'epidemic of ill-health, both physical and mental' (ibid.). His open-access articles called on the Scottish public to not be intimidated by lockdown restrictions and police fines: 'I personally have decided I will make a point of breaking the law. Judging by the number of people now going out for walks, people have now decided to vote with their feet' (ibid.).

Kempe's narrative during the Covid-19 pandemic reveals a continuation of the construction of Scottish landscapes under geographies of tolerance: constructed as spaces of health and safety, these landscapes were incapable of transmitting disease, thereby locating disease away from the landscapes and onto the politics of lockdown. Interestingly, this reveals geographies of tolerance as a cycle: as human-landscape relationships render the bacteria safe, so human-microbial relationships then render landscapes safe. While the Scottish landscapes may have been safe from the dangers of SARS CoV-2 infection, the above mapping by Lyme patients and epidemiologists reveals that these landscapes were not safe from *B. burgdorferi.*

However, the pandemic was having its own impact on *B. burgdorferi*, by transforming it from safe to invisible. For Dr Lucy Gilbert's doctoral students, inaccessibility to Scotland's landscapes was "a complete disaster." Speaking to me via Zoom in June 2020, Gilbert continued:

> Obviously the university has closed completely, you can't work in the labs, no one's allowed access. All the analyzing ticks for *Borrelia* has had to stop. Fieldwork's gone completely. I have no idea what the tick situation is.

The pandemic placed her doctoral students onto unprecedented professional courses and jeopardized important data in mapping *B. burgdorferi* in Scottish landscapes. Gilbert elaborated:

> One student should be in her final field season. She was doing lots of live trapping of rodents, counting ticks on them, and assessing their numbers, and counting deer dung last year. The idea was that *this* year she'd go back to those exact sites and survey for ticks. In effect she's lost two field seasons because obviously she can't catch the nymphs this year, which means that the rodent data last year is completely useless. She's just lost two years!

In Gilbert's own work, access to Scottish landscapes was complicated by unprecedented questions of ethics, health, and trust with the people who lived near her field sites. As Lyme disease is not an infectious disease, there were never any anxieties over contagion. Now, her work took on a new form of danger:

> There's the extra sensitivity in the Scottish islands. Even if Nicola says, 'Yes, you are now allowed to be free again', the locals don't want us. We really don't want to annoy or upset the locals in any way. Let alone give them Covid.

Although the islanders recognised the importance of researching tick-borne infection in their landscapes, that particular bacteria had to wait. The most important pathogen now was SARS-CoV-2.

On 29 May 2020, Scotland entered Phase 1 of easing lockdown restrictions and for the first time since the start of the pandemic, Scottish residents could sit in their local parks. On the 3rd of July 2020, First Minister Nicola Sturgeon announced unlimited travel access: outdoor tourism could resume and the Scottish

landscapes were again officially accessible. The correlation was clear: a return to the outdoors was a return to health. After being housebound for months, Scottish residents exploded out into the green spaces with joy and fervor. Recreational spaces such as gyms and cinemas were still closed due to lockdown regulations, so city-dwellers traveled to the rural green spaces. A further movement into the hills came as a consequence of the Black Lives Matter (BLM) movement of 2020: as Dumes describes in her work, ''nature' continues to be broadly perceived and experienced as a 'white space'' (2020, 73) and that summer, there was a conscientious push in Scotland to attract People of Colour to Scottish hillwalking groups and into outdoor rural spaces. As a Woman of Colour and an avid hillwalker, I welcomed the overdue discussion of why nature spaces are predominantly white, but this also raised a different question in my work: if the Scottish landscapes are constructed as inclusive and safe from SARS CoV-2, are first-time hillwalkers being given information on Lyme disease? What role do hillwalking groups play in providing information on ticks, symptoms of infection, and the diseases in the landscape other than Covid-19?

In June 2020, I asked Kevin Lafferty, the Access, Health and Recreation Advisor for Forestry and Land Scotland about the landscape maintenance during the pandemic and what preparations were in place to prepare them for an increased influx of humans. He replied:

> During Covid, the majority of staff worked from home. So, we haven't had the same level of forest management bracken or brush cutting. Sites have become overgrown. Skeleton staff remain out maintaining infrastructure and buildings, only going back out to trim and cut. Our staff are reporting that it's so far been a very ticky season but no signage and no information has been put out on tick awareness because no one has been out to do so.

Unfortunately, as epidemiologists, ecologists, and forestry managers work through the backlog of work on *B. burgdorferi* paused during the pandemic, the compounded effect of easing lockdown restrictions, the increased number of hillwalkers and the untended landscapes had on tick bites and *B. burgdorferi* infection rates are currently unknown. One thing, however, became abundantly clear in summer 2020: the social construction of Scotland's landscapes as beautiful and safe remained intact, as did their inability to be diseased and dangerous. Lafferty confirmed that an influx of people were entering landscapes under the management of Forestry and Land Scotland:

> We can monitor that they're using the sites because we have electronic people counters, staff live next to the sites we manage and see them, or we see the forests filling up that are near towns and cities.

While Scottish landscapes are socially constructed as pristine, beautiful, and safe, they also carry the highest incidences of *B. burgdorferi* in Europe (Ling et al. 2000). Can these two truths be reconciled? To approach this question, this article has offered geographies of tolerance as a framework to examine our own notions of risk and how we can communicate risk, disease, and epidemic preparedness better, both to the public and to ourselves.

Conclusion

We dream of Scotland's landscapes – and quietly woven into those dreams are the bacteria. They are in the stories that aren't told, in the absence of signage, leaflets, and conversations. They haunt landscapes, they inspire defiance, anger, fear, self-blame, and trauma. They demand preparedness, tools, and knowledge.

Bacteria continue to be obscured by powerful ideas of safety, but safety is messy, complex, and constantly negotiated (Vogel 2013) – a perfect hiding place for bacteria.

The *B. burgdorferi* bacteria has long been caught in a tension of visibility and invisibility, with a primary focus on medical knowledge production, the Lyme wars, and the growing private economy of healthcare. While epidemiological and entomological research on Lyme disease is increasingly making *B. burgdorferi* visible in Scottish landscapes, research on the intersection between humans, landscape, and disease is at the beginning. This article therefore builds on existing literature of human-bacteria relationships as co-existence to respond to Ostfeld's (2011) call for more research and to work in dialogue with Ribeiro (2021).

I began with an analysis of epidemiological mapping in Scotland to understand the burden of Lyme disease across the landscapes. The inclusion of apps and online participatory maps is currently making a co-construction of microbial knowledge between Lyme patients and epidemiologists possible. This is important as collaborations between the two parties have often been fragmented by the tension of the Lyme wars. The intersection of landscapes, people, and bacteria therefore represents an exciting space for possible future collaboration, communication, and the co-construction of knowledge between Lyme patients and Lyme researchers.

During interviews with patients, it was interesting to watch landscapes become obscured by the dominant narratives that Lyme disease research commonly focuses on. Unraveling this dominance by exploring how human-bacterial relationships socially render (Koch 2011) landscapes and how else we can understand bacteria intra-action (Hinchliffe et al. 2013), allowed important new patient stories to come to the fore: how Lyme patients map where and how they became infected. This allowed a new understanding of the social construction of Scottish landscapes by patients along a continuum of defiance, risk preparedness, vigilance, anxiety, and fear. The stories of Lyme patients hold important lessons on how relationships to landscapes are impacted by the bacteria, obscured, and made invisible when other narratives of illness become dominant. This is a reminder of the importance of place in health and disease: it demonstrates emotions people feel towards landscapes; it highlights how important it is to interrogate the dominant, nation-wide social construction of landscapes; and it shows how many more patient stories we have yet to hear.

To think through how human-landscape relationships render the bacteria safe, I offered the framework geographies of tolerance, which describes how spaces are constructed as safe, and how the animals, bacteria, and diseases found in these spaces are equally assigned safety. This framework explores how human-microbial relationships become a cycle that renders landscapes safe, which then renders the bacteria safe. I offered the framework of geographies of tolerance as a way to think through the UK's slow response to the fatal Covid-19 pandemic. Understanding how the UK and Scotland view themselves as spaces of intrinsic safety helps us understand why bacteria like B. burgdorferi and SARS CoV-2 are assigned baffling safety. B. burgdorferi is an important and necessary bacteria for this research, because the Scottish Highlands and Islands hold the highest incidence of Lyme disease in the UK, and one of the highest in Europe. The framework of geographies of tolerance could therefore be a useful tool for locating future challenges to disease prevention and risk communication and unmaking the invisibility and safety of certain bacteria.

My hope is that this article points to some of the important research needed in the future. One is a standardization of real-time tick maps in public awareness. While projects like LymeApp and the *What Makes*

Virus Tick? TickMap are hopeful steps towards open-access maps, more research is needed into public awareness of these maps; how often these maps are used by people moving through landscapes; how helpful they are in communicating risk and preventing infection; and which platforms ultimately dominate in popularity and use, why, and what we can learn from this for future risk communication. Another area is the growing health practise of prescribing nature walks. This builds on past relationships between landscapes and the prescription of their health benefits, such as nineteenth-century treatment for tuberculosis by prescribing time in certain landscapes, and on Dumes' work on landscapes as holding 'health benefits' (2020, 74) and 'personal and cultural benefit' (ibid., 75). Nature walks in Scotland for mental and physical health must include information on Lyme disease, and it will be important to assess to what extent these walks as a health practice make *B. burgdorferi* visible or invisible; and what, if any, correlation exists between health walks and Lyme disease infection. Finally, this article has hoped to emphasize the important role of microbe-landscape interactions in the multispecies studies on health and illness. As a growing epidemic, the importance of research on Lyme disease cannot be overstated, so I hope this article excites future medical anthropologists to this research.

Acknowledgements

Thank you to everyone who contributed to this research, in particular Professor Ian Harper, Dr Rebecca Marsland, Dr Alice Street and Dr Bridget Bradley; my research participants Joanne, Janey, Anne, and everyone from 'Lymediseasealba'; Dr Rita Ribeiro, Dr Lucy Gilbert, Professor Dominic Mellor, Kevin Lafferty, and Dr Kate Harrison; everyone at the Edinburgh University Hillwalking Club; and all my hillwalking buddies around Scotland, especially Benedictine Khor and my dog Rumi. Thank you to my reviewers for all their invaluable comments in making my work the strongest it can be.

The doctoral research for this article was funded by the PhD Scholarship with The Carnegie Trust for the Universities of Scotland.

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