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The digital peregrine: A technonatural history of a cosmopolitan raptor

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Abstract

Humans, non-human animals, and technologies are increasingly entangled. Using the peregrine falcon (*Falco peregrinus*) as an illustrative example, we propose 'technonatural history' as a theoretical and methodological approach for observing, describing, and examining the role technologies play in shaping human relations with other species. After nearing extinction in the 20th century, peregrines have become woven into the fabric of everyday urban life and are a frequently sighted urban raptor in the UK, nesting on high-rise buildings and church spires since the late 1990s. Their unexpected presence in cities symbolises hope for multispecies conviviality amid the contemporary ecological crisis. As their populations resurged, crucially, webcam and livestreaming technologies developed rapidly. Peregrines were one of the first animals to be broadcast over the internet via 'nestcams', granting broad publics access to their intimate lives. We examine the related technological histories of livestreaming technologies and natural histories of peregrine falcons in the UK, tracing the emergence of 'the digital peregrine' and its manifold implications for more-than-human and digital geographies. To do so, we build on oral history interviews with people associated with digital peregrines throughout the UK: nestcam technicians, peregrine conservationists, professional ecologists, activists, and citizen scientists. While digitisation brings broad publics closer to these cosmopolitan raptors, they can only ever grasp at the wildness of peregrine falcons and their wider milieus as the digital peregrine is a distinct entity, encountered via its own set of affects and affordances. In the peregrine's case, digital technologies create unexpected and radical opportunities for urban conviviality, signalling the positive potentials technologies host for forging meaningful more-than-human connections.

KEYWORDS

digital ecologies, livestreaming, nestcams, peregrine falcon, technonatural history, urban ecologies

1 | TECHNONATURAL HISTORY AS METHOD AND THEORY

The spire of St George's church in central Sheffield has been home to peregrine falcons (*Falco peregrinus*) since 2012. In that year, a nesting box ('nestbox') was erected to improve the breeding success of these charismatic birds of prey. Two CCTV cameras were installed in the nestbox, publicly livestreaming video 24-hours-a-day. One of these 'nestcams' gazes across the nestbox, offering human observers access to peregrines' everyday lives: feeding, breeding, laying and hatching eggs, and the rearing—and eventual fledging—of chicks. The other draws the observer's attention to a metal perch outstretched from the spire. Here, the adult peregrine spends most of its time, patiently observing the cityscape below for prey. This image has become iconic, particularly at dawn and dusk, as the peregrine's silhouette contrasts with the city and, in the distance, the rolling hills of the Peak District. Plumes of smoke rise from Sheffield's chimneys, fading into the sky above. Visions of this landscape, and of the specific nonhumans which make it appealing, are only rendered possible through the technological process of digitisation. Via nestcams and on screens, the peregrine becomes digital: the digital peregrine takes flight.

Peregrines are 'charismatic' birds of prey, or raptors (see Lorimer, 2007). They are fierce predators, reputedly the fastest animal on Earth (Macdonald, 2006). With 19 subspecies, *Falco peregrinus* is distributed globally, present from tundra to tropics. In this paper, we examine the entangled histories of livestreaming technologies and peregrine falcons in the UK, tracing the emergence of the 'digital peregrine' and its implications for more-than-human and digital geographies. We focus specifically on how the digital peregrine is co-produced, both through the streaming of data and the way these data are processed, observed, and embodied by diverse publics. The digital peregrine occupies a liminal space, in perpetual translation between physical and cybernetic forms, and is an object of mass culture: in the UK alone, at least half a million minutes of nestcam footage are livestreamed online every week.[1]

We begin with several exploratory questions. Given digital media have proliferated in 21st-century everyday life, what are the implications for practices of 'natural history'? Specifically, how might geographers rethink and repurpose natural history to account for the increasing entanglement of species and technologies in the digital age? What does this rethinking offer geographers interested in complex relations between society, ecology, and technology? And how are digital technologies altering human relations with nonhuman life, particularly in the context of urban ecologies (see Moss et al., 2021)? We now turn briefly to the wider geographical fields to which this paper contributes, before elaborating our development of technonatural history.

Environmental humanities scholars have long been interested in human–avian relations (e.g., Petri, 2019; van Dooren, 2019; Wrigley, 2018). Amid these recent 'winged geographies' (Petri and Guida, forthcoming), there is specific interest in urban birds and digitised birdwatching activities. In relation to urban birds, Wilson (2022) describes how kittiwakes—usually a coastal species—have become part of urban life in North East England, repurposing buildings as breeding cliffs. Similarly, Barua (2021) examines the recombinant ecologies of parakeets and peregrines in London. Regarding digitisation, Jonathon Turnbull et al. (2022) explore how digital technologies enable broad participation in birdwatching through a case study of the Self-Isolating Bird Club. Herein, we draw from and converse such studies of urban and digital ecologies.

'Digital ecologies' is an emerging body of research examining the potentials and pitfalls of digital technologies in mediating human–nature relations. Regarding human–non-human encounters, digital mediation is actualised for: entertainment (e.g., interactive live-streaming; Oliver, 2021); education (e.g., enhancing public attunement to wildlife; Blue, 2016); activism (e.g., surveillance/policing; Fish, 2022); governance (e.g., Arts et al., 2015); controversial purposes like hunting (von Essen et al., 2021); and research (e.g., Verma et al., 2015). Emerging work on 'smart forests' is exemplary of digital ecologies research, showing how woodland habitats are becoming digitised for measuring, managing, and mitigating environmental change (Gabrys, 2020; Prebble et al., 2021). As digital technologies become entangled with—and sometimes inseparable from—various organisms, cyborg entities emerge; fusing natural histories of species and technologies, often in urban environments. To tell the stories of certain species, we must tell the stories of the technologies they're entangled with. Hence, this paper advances the notion of 'technonatural history'.

Natural history was added to the British school curriculum in 2022, in part driven by nostalgia, ecological anxiety, and a desire for increased societal ecological awareness (The Guardian, 2022). Most often associated with observational—rather than experimental—modes of enquiry into organisms and their environments, natural history is a long-established field (Allen, 1976), born from novel practices of ordering nature developed in the 17th century (Foucault, 2002; Gabrys, 2011). Natural history's emphasis on the influences that surround and shape bodies, as well as species–species interactions, led to the 18th-century conceptual development of *milieu* or environment (Benson, 2020).

As Gabrys writes, 'there have been multiple versions of natural history' (2011, p. 162). Indeed, 'no single definition [of natural history] will satisfy all readers' (Tewksbury et al., 2014, p. 300). Present-day natural history includes the patient observation of organismal behaviour—a detailed and 'descriptive' form of ecology and ethology (Greene, 2005)—and the study of organism–environment relations (Barrows et al., 2016). But it is also articulated via popular nature-writing, nature documentaries, educational podcasts, journal articles, and museum exhibitions. Crucially, natural history offers a form of immersive and qualitative enquiry, rather than being detached and quantitative (Barua, 2021). Its emphasis is on both material and affective relations between humans, non-humans, and environments.

Among scientists, though, natural history has long been in decline. Marie Tosa et al. (2021), however, suggest that 'next-generation natural history' is transforming conventional practices of describing the natural world. Digital technologies such as miniature tracking devices, trail cameras, remote sensing, and computation allow the systematic collection of repeated and detailed observations over broad areas. These technologies heal the rift between natural history and formal biological science, and reposition natural history observations as robust contributions to scientific inquiry. Sophisticated technologies transform the anecdotal character of natural history through generating systematically collected observations using remote and non-invasive methods (Tosa et al., 2021). However, Tosa et al.'s version of next-generation natural history remains rooted in scientific discourse, which privileges the collection of data predominantly as an input to scientific theorisation. Here, we want to tell a different story; of the entanglement of human, animal, and technological worlds. We are interested in the role technologies play in an organism's socio-ecological milieu. We follow Gabrys' provocation to take up 'natural history as much as a method as a theoretical point of view' (2011, p. 13). Using the peregrine as an illustrative case, we forward 'technonatural history' as a specific mode of inquiry for understanding and conceptualising the relations of humans, non-humans, technologies, and the lived environment.

In practising technonatural history, it is unhelpful to suggest an absolute distinction between 'real/actual' and 'digital/virtual'. This distinction often diminishes the value of encounters with/in/through the digital (Ash et al., 2018; Leszczynski, 2015). We embrace Jessica McLean's (2020) 'more-than-real' conceptual frame, considering digital mediation as productive of multispecies contact zones (Haraway, 2008). Nevertheless, the digital peregrine encounter is experientially different to encounters with corporeal peregrines, producing a distinct set of affects and affordances. Moreover, while digitisation brings broad publics vastly closer to these raptors, it produces a limited version of free-flying peregrines and their wider milieus.

Digital peregrines are multiple, coming into being via several trajectories. They exist as images, streams of data, and in server farms around the world (Adams, 2020). They are stored in databases, transmitted via satellite technologies, analysed by computer programs, and presented in a variety of visual formats on screens. In the scientific realm, digital animals are often produced using GPS-tracking technologies. A team of ecologists in Italy, for instance, attached GPS-trackers and video cameras to juvenile peregrines to study their predatory behaviours (Brighton et al., 2017). Here, though, we specifically focus on nestcam mediation. Unlike tracked animals, nestcam digital peregrines are publicly accessible, and widely so. They are encountered by massive quantities of people simultaneously on computers and smartphones around the world. Indeed, they were instantiated to reach a broad audience—created to travel, to be seen, to evoke responses—and have acquired cultural significance like no other form of digital peregrine. Their cultural significance and global reach give the digital peregrine its cosmopolitanism. Cosmopolitan animals are 'present the world-over and not just 'out there' in beastly places' (Barua, 2014, p. 560; see Philo & Wilbert, 2000). Digitisation contributes a novel dimension to cosmopolitanism; complexifying these relations and rendering species multiple, multimodal, and massive (Rose, 2015).

This paper builds on oral histories of people working closely with digital peregrines throughout the UK (20 interviews): nestcam technicians, peregrine conservationists, ecologists, activists, and citizen scientists.[2] Interviews were conducted online from March 2020 to May 2021, transcribed, and analysed as text. To examine the digital peregrine's societal co-production, we asked the managers of seven popular peregrine nestcams to advertise an online survey to their followers. We draw on the results of this survey (455 responses) in section 4. We also draw on our own observations and interpretations of the online discourses surrounding moments of drama, contention, and ecstasy revealed in the comments sections of nestcam websites. Furthermore, we were granted access to the online metrics of prominent nestcams, allowing us to identify the events which drew greatest attention. We used a keyword search on popular search engines and streaming platforms to identify the 50 most popular nestcam streams in the UK to help identify our interlocutors and to determine the geographical and historical proliferation of nestcams.[3] Although individual nestcams have unique stories, multi-sited comparison allows us to narrate the digital peregrine's story across the UK.

2 | PEREGRINATIONS THROUGH THE PAST

For a technonatural history of the peregrine, it is important to contextualise its story in specific historical, cultural, and geographical milieus. Here, we trace the peregrine's history from near extinction to resurgence and urbanisation in the 20th century.

Nature writer Helen Macdonald's *Falcon* (2006) evidences the intertwining of peregrines and human culture. Peregrines, Macdonald (2006, p. 7) writes, 'excite us, seem superior to other birds and exude a dangerous, edgy, natural sublimity.' By projecting these cultural concepts onto nature, encounters with peregrines become 'encounters with ourselves' (2006, p. 8). The first sighting of a peregrine persists in the observer's memory (Macfarlane, 2017) and watching them stoop (dive on prey) is spectacular. A successful stoop is 'one of the supreme and dramatic events in natural history and its witness is never forgotten' (Schwab & Maggs, 2004, p. 4). Until recently, most could only dream of such encounters due to the rarity of peregrines.

In the 19th century, peregrines were persecuted as predators of game birds in the UK, and remain the targets of illegal killing by some gamekeepers and members of the pigeon-racing community who resent their predatory activities (Humphreys et al., 2007; Ratcliffe, 1993). During the Second World War, peregrines were 'outlawed as a killer of carrier pigeons,' persecuted by the Air Ministry in the interests of Britain's war effort (Ratcliffe, 1963, p. 64). The British peregrine population later declined sharply due to widespread organochlorine pesticide use (Ratcliffe, 1970). Cyclodienes applied as insecticides to seeds caused mortality in seed-eating birds and bioaccumulation and eggshell thinning in their predators (Weaving et al., 2021). By the 1960s, the UK peregrine population had fallen by 80% compared to its pre-war abundance (RSPB, 2021).

In the mid-20th century, peregrines had achieved quasi-mythical status in the UK. In *The Peregrine* (2017 [1967]), nature writer J.A. Baker wrote 'before it is too late, I have tried to recapture the extraordinary beauty of this bird.' Baker predicted their continued plight: 'few peregrines are left, there will be fewer, they may not survive. Many die on their backs, clutching insanely at the sky in their last convulsions, withered and burnt away by the filthy, insidious pollen of farm chemicals' (2017, p. 32). Empty eyries and broken eggshells came to define the raptor. Nature writer Tim Dee captures a generational sentiment, writing that he 'grew up thinking of peregrines as sickly' (2009, p. 89). They were once 'rare and remote things glimpsed in distant or severe places,' now 'ruined by the malign human idiocies that were contaminating the whole world' (2009, p. 89).

Eventually, widespread public campaigning supported by biological research led to pesticide bans (Ratcliffe, 1963, 1970; Sheail, 1985). With strict protection under the Wildlife and Countryside Act 1981,[4] raptor populations began to recover slowly (Tucker, 1998). Peregrines became a '*cause célèbre* for nature conservation' (Ratcliffe, 1972, p. 118). By 1991 there were 1283 pairs of breeding peregrines in the UK (Crick & Ratcliffe, 1995).

As peregrines recovered, their habitat expanded from rural cliffs into anthropogenic environments (Banks et al., 2010; Dixon, 2000). The remarkable urban adaptation of peregrines is explained through four main factors: raptors generally do not conflict with city-dwelling humans (Pagel et al., 2018; Washburn, 2018); urban ecologies provide ample prey (Dixon & Drewitt, 2008; Kettel et al., 2019; Mak et al., 2021b); urban infrastructures enhance predation due to artificial lighting and heating (Kettel et al., 2016; Stirling-Aird, 2015); and buildings like skyscrapers and cathedral spires mimic the vantage points required for hunting and nesting, which were historically limited to cliffs (Drewitt, 2014). Peregrine urbanisation involved changes in territory, behaviour, and ecology, and recast peregrines as conservation flagship species in an era of extinction (Donázar et al., 2016; Schroer, 2021). Previous epistemological frames used to understand peregrines were unsettled by their presence in urban space. These elusive animals were rewritten into the fabric of urban life (Hennen & Macnamara, 2017).

Peregrines' resurgence from extinction recast them in recombinant and cosmopolitan ecologies (Barua, 2014, 2021; Hinchliffe et al., 2005; Hinchliffe & Whatmore, 2006; Jalais, 2008). We seek to further narrate the peregrine's resurgence as deeply entwined with digital technologies. Indeed, peregrine resurgence runs parallel to the development of certain technologies, and they would not have the public status they do today if not for this historical co-development. We thus contribute to a growing literature concerning the use of digital technologies in conservation (Adams, 2019; Arts et al., 2015; van der Wal & Arts, 2015; Verma et al., 2015) and in mediating more-than-human relations (Chambers, 2007; Stinson, 2017; Turnbull et al., 2020a).

3 | THE DIGITISATION OF A COSMOPOLITAN RAPTOR

According to Rachel, a raptor ecologist, most UK-based nestcams were established after 2016. Maria, who runs a nationwide network of peregrine conservationists, told us that 'there must be well over 100 nestcams.' Following our analysis

of UK nestcams, only 16% were established before 2010, and 36% before 2015 (Figure 1), signalling a recent surge in peregrine digitisation. This digitisation has brought peregrines before the public on a large scale, and in an entirely new way. Here, we examine the history of peregrine digitisation and explore its consequences for the ways peregrines are understood and governed today.

3.1 | Digital capture

Sussex Heights, a 24-story residential block on the Brighton seafront, is no stranger to controversy. Commentators refer to the structure as 'damaging' to the Brighton cityscape as it uncharacteristically towers over the surrounding 18th-century architecture (Antram & Morrice, 2008). Although the tower obscures the ocean for many human inhabitants of Brighton, this topographical contrast provides the ideal vantage point for its resident peregrines (Figure 2). Tall buildings surrounded by low-lying spaces mimic cliff sites, offering 'commanding views of the surrounding landscape' (Mak et al., 2021a, p. 7). The relative height allows for peregrines to observe their surroundings, while providing them time to increase their stoop speed and consequential predation success (Drewitt, 2014; Jenkins, 2000; Ratcliffe, 1993).

Conservationists erected a nestbox above Sussex Heights to encourage peregrine breeding in March 1998 (Drewitt, 2014). A CCTV camera was simultaneously placed on the nestbox, the first peregrine nestcam in Europe (Figure 3). Fraser, the ecologist who erected this nestcam, holds a Schedule 1 licence, meaning he is legally permitted to interact with the nests of protected species. He originally used videotapes to record peregrines, which were 'collected by a courier once a week for local television, where they got quite popular.' While being interviewed by BBC South about the peregrines, he met someone from an amateur 'Video Repeater Group' that in 1998 had just livestreamed one of their members drinking a can of beer. 'They reckon it was one of the first livestreamed videos on the internet. I said, 'that's good, but it's only a beer, why can't we do that with the Brighton peregrines?'' Soon after, beamed via a microwave link from the roof of Sussex Heights to a house a few kilometres away in Hove, live images of a peregrine falcon were transmitted over the internet for the first time in Europe.[5]

Mark, who has installed wildlife cameras since this time, reflected on the technologies available in the late 1990s: 'it was all analogue cameras, in standard-definition quality. Even with unlimited bandwidth, the largest resolution you could get with standard-definition was 756 × 576 pixels; that's a quarter of your standard high-definition resolution.'

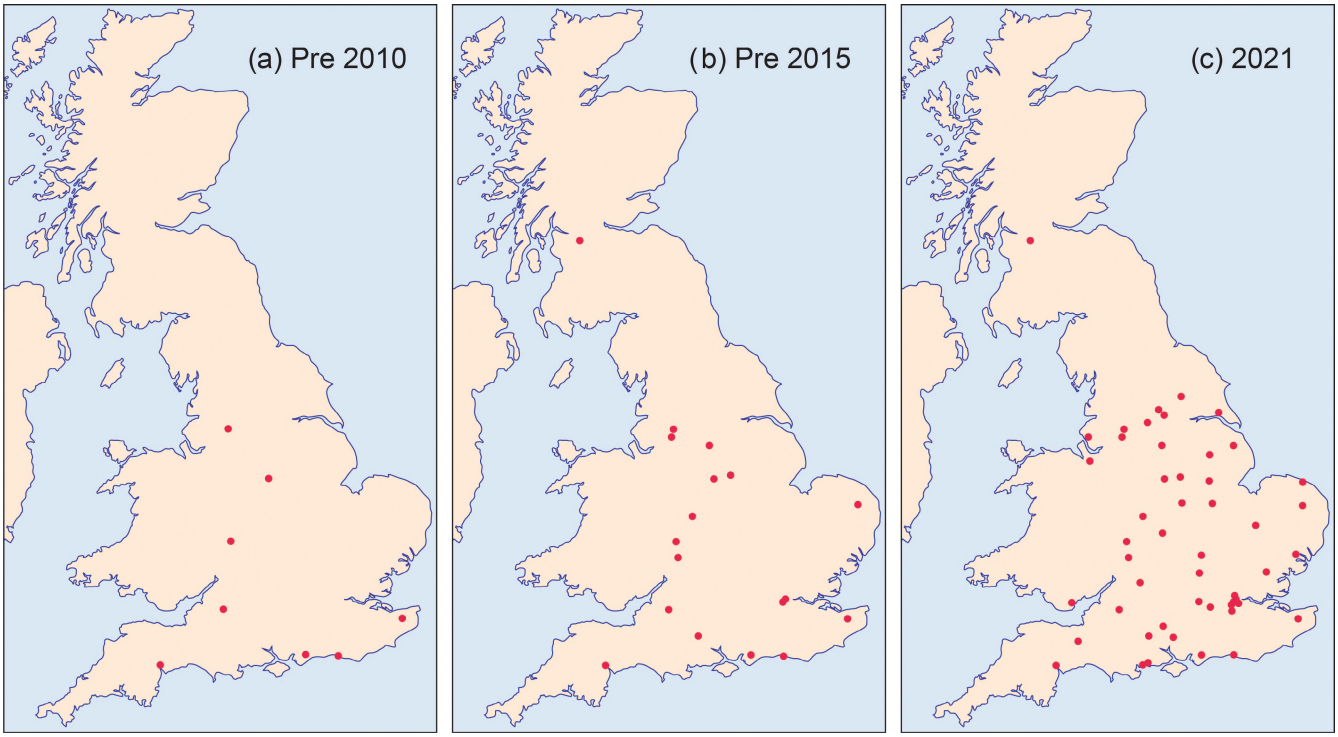

FIGURE 1 Growth in UK peregrine nestcam popularity from 2010 to 2021, illustrated by when nestcams went online.

FIGURE 2 A resident peregrine wanders beyond the nestbox above Sussex Heights on the Brighton seafront.
Source: Photograph by Graham Roberts. Reproduced with permission.

During the late 1990s and early 2000s, the 'webcam era' was just coming into full swing (Koskela, 2003). The first webcam was developed in 1991 and first streamed online in 1993 (Campanella, 2004). Mark explained that the 'jpeg refresh' nestcams used in the early 2000s would deliver a series of static images refreshing 'every ten or thirty seconds.'

The ability of viewers to watch distant locations in real-time, even if lagged, engendered 'something of a revolution in our perceptions of time, space, and global geography,' which 'was for all practical purposes an impossibility' prior to this technological development (Campanella, 2004, p. 59). Webcams bridge the physical and cybernetic, harnessing the agencies of both (Campanella, 2004). The 'body individuals' they capture 'become, in one sense, intertwined with digital individuals' (Koskela, 2004, p. 200). Peregrines captured on nestcams and broadcast over the internet operate on this threshold; the digital peregrine is an assemblage of corporeality, data, and visualisation practices. Not only had the presence of peregrines in urban spaces been unimaginable just decades prior, so too had the technological capacities to observe the intimate lives of these charismatic animals in real time from locations around the world (Figure 4).

The Sussex Heights nestcam led to wider excitement about peregrines in British cities. Nigel, an ecologist who studies predation using nestcams, reflected: 'the older generation remember how rare they once were; there's still a sense that this is a very special bird.' Nestcams were a way of sharing this excitement. Other sites were quick to install nestcams for the following breeding season and by 2001 Exeter and Bath cathedrals both had livestreaming nestcams. Mark described these set-ups as 'complicated': they converted analogue camera footage into digital signals through a third-party programme, which were later 'uploaded to content delivery systems and hooked into servers around the world.'

For Nigel, these technologies instigated a paradigm shift in peregrine observation and knowledge: 'up until 20 years ago everything we knew about peregrines was from cliff nesting peregrines seen—looked at—through a telescope. Whereas now we've got these insights into their lives, their intimate lives.' As peregrines became more present in urban

Evening Argus

NIGHT FINAL

MONDAY, MARCH 23, 1998

28p

Picture: Jim Holden

35337-A33

THE HEIGHTS OF FASHION: Sussex Ornithological Society member Graham Roberts checks the metal nesting box position

Penthouse suite put up for a pair of peregrines

by Tim Bowden

PLANS to help rare peregrine falcons breed in Brighton today took a major step forward.

Members of the Sussex Ornithological Society and the RSPB fixed a metal nesting box on the roof of the town's highest residential building.

A pair of spectacular peregrines have been spotted on the top of the 336ft-high Sussex Heights, the 24-floor luxury tower block on the seafront.

If the box is successful, it will be

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FIGURE 3 Installation of the nestbox and nestcam at Sussex Heights, 1998, as reported in the *Brighton and Hove Evening Argus*.
Source: Newspaper clippings from the personal archive of Graham Roberts. Reproduced with permission.

FIGURE 4 Four images from the 2001 breeding season from the Sussex Heights nestcam. From left to right, they show a clutch of eggs in the nest while the adults are hunting, 30 March; the hatching of the first egg, 4 May; the chicks being fed by an adult peregrine, 22 May; the adult peregrine feeding the young, now in juvenile plumage, 6 June.
Source: Photograph by Graham Roberts. Reproduced with permission.

environments, digital capture of their quotidian lives evolved at an astonishing rate, through developments in both hardware and software.

The nestcam system at Norwich Cathedral was set up in 2011. By this time, CCTV apparatus was able to capture and share a continuous signal. Stuart, who installed it, recounted that 'this was still the old technology, analogue cameras,' meaning that video footage was transmitted via cable and digitised elsewhere. Stuart added, 'we outsourced these images to an American company, called Axis, who sold equipment called a video server—an analogue to digital server.' In late autumn 2014, when the peregrines were absent from their nest, Stuart and his team upgraded the system with commercially available IP cameras. 'The beauty of these things,' he told us, 'is that the camera system itself will convert

the analogue signal to an IP signal—a stream. With our own signal, we were able to stream it out to our own distribution system and present it to the public.' This hardware shift gave those who manage peregrine nestcams the freedom to directly manage data.

IP cameras brought other benefits, like enabling the use of high-definition cameras, which fostered more intimacy between viewers and peregrines. Today, some cameras are fitted onto a 'pan, tilt, zoom' system, which enables controllers to manoeuvre their view around nesting areas to capture intimate moments in even more detail. Daryl, who works with citizen scientists to observe peregrine activity using nestcams, added that an important shift was the ability to 'stream high-quality audio.' The ability to listen, closely, to a wild peregrine's nest was previously unimaginable. Not only are nestcams able to enhance human sensory exposure to digital peregrines, they are also able to broaden sensory capacities of observation. Stuart explained that 'all the modern cameras are capable of operating in both daylight mode and infrared mode,' enabling what Daryl called '24/7 observation.' Infrared cameras have provided evidence of nocturnal hunting in light-polluted urban environments, which was previously unknown to science (Kettel et al., 2016). Livestreams broadcasting peregrines have gradually become more sophisticated, with better image quality, the incorporation of sound and infrared, and less lag. This has allowed for more diverse forms of sensing.

Cities not only provide ideal peregrine habitats, they also provide the infrastructures necessary for humans to observe their activities using digital devices. The 'digital divide' between rural and urban regions of the UK is well documented (Philip et al., 2017; Riddlesden & Singleton, 2014) and nestcams are no exception to this. Stuart told us that 'getting cameras to a cliff edge, and streaming that to the internet, well, that's a significant problem that you don't have in a city. You might have to run a bit of fibre optic cable up a cathedral spire,' he added, 'but it's hardly two or three miles, which is not only cost prohibitive, but also technically limiting.' Rachel noted that this technical divide had been scientifically limiting in her fieldwork. She explained that 'it was too difficult to get peregrine nestcams to work in rural areas,' but she 'was able to observe twenty different urban sites at once.'

Software improvements have been equally important. In nestcams' technological infancy, when third-party software was used, sites were obliged to set up their own streaming services. Old systems 'were sending up a stream to a server,' Mark explained, 'and when someone clicks on the website, they'll get sent an exact copy from the server itself. All that throughput costs money, and the more traffic, the more cost for bandwidth.' Rachel recalled that during the mid-2010s 'it was really expensive for organisations to constantly livestream.' During the COVID-19 pandemic in 2020, the popularity of nestcams surged and many providers were overwhelmed by the unprecedented traffic (Turnbull et al., 2020a, 2020b). Because of this, Mark told us, 'many nestcam hosts have switched to YouTube now ... it throws adverts at people, but it's free for the cameras.' As a result, urban peregrines have been enrolled in the affective economies of lively capital, generative of what we term 'digital encounter value' (cf. Barua, 2016, 2020).

3.2 | Security and governance: 'Hiding in plain sight'

During the early days of peregrine resurgence, conservationists publicly obscured peregrine whereabouts to prevent persecution. Simon, an ecologist, told us that his report of a peregrine pair in the Peak District in the early 1980s was rejected by the British Trust for Ornithology: 'They were suppressing the records, they didn't want people to know peregrines were nesting nearby ... collectors could sell a peregrine egg for more than £3000—that's a lot of money when unemployment was at 25% in Sheffield.' Clive, who installed the UK's second nestcam in Exeter in 2001, told us that in the early 1990s 'another birdwatcher told me he'd seen a 'P', instead of saying peregrine. People in the know felt a part of this secret.' 'P' enthusiasts developed secret codes and rules for the sake of peregrine protection.

Once nestcams proliferated, though, secrecy was impossible to maintain. Nestcams broadcast the locations of peregrines to the public-at-large in most cases, save for a few exceptions where human privacy might be compromised in delicate spaces such as hospitals or schools. Clive reflected that 'at times, at the start of the peregrine comeback, it all felt like a secret, but that was before webcams ... now, sometimes you've got to be totally open to keep them safe.' Yet peregrines remain at risk from persecution, which according to Daryl was mostly from pigeon fanciers: 'some of them lace the pigeons with poison and try to bait the peregrines into eating them.' However, nestcams provide vigilance around the clock—anyone could be watching at any time in the urban polyopticon (Allen, 1994). Kevin, who manages one of the most popular nestcams in the UK and defines himself as a 'natural historian,' thought that allowing broader publics to observe the birds would encourage more people to care: 'having the webcams, and building up a following,

makes the peregrines secure. It's this 'hiding in plain sight' idea.' Simon told us he'd 'always thought it best to get the information out there so that people will look out for them. With webcams, the public do a lot of the watching for you!'

Combined with infra-red technologies and continuous livestreaming, vigilance is rarely dropped around UK peregrine nestcams. 'You can have people watching throughout the night,' Nigel explained. 'People that don't sleep or work shifts ... you've got people that care, and you've got people watching all the time.' Nestcams actually inaugurate new modes and practices of care. Several participants spoke of receiving emails and calls from concerned members of the public reporting fallen chicks. On occasion, this led to them being recovered and placed back in the nestbox.

Nestcams for other raptors are popular in rural sites where they nest in more accessible places than historical cliffside peregrine eyries. The Loch Arkaig osprey camera in the Scottish Highlands, for exam is among the most popular in the world.[6] In some of these sites, persecution remains a genuine concern for conservationists despite nestcam surveillance. In May 2021 footage emerged of vandals felling an osprey nesting platform on the Llyn Brenig reservoir in Wales, just a few hours after an egg was laid (Morris, 2021). In comparison, urban peregrines are rarely met with hostility from city-dwelling humans, who usually are, at their worst, 'indifferent' to the presence of peregrines (Bildstein & Therrien, 2018). Importantly, urban peregrine nesting sites are considerably safer due to their sheer inaccessibility for persecutors. Ringo, who uses nestcams to monitor fledging, pointed out that 'peregrines in places like universities or cathedrals are probably pretty safe. In these big cities, there's CCTV everywhere.'

Cities emerge as spaces of refuge for peregrines, aided by the social networks of digital guardians. As mentioned in the opening vignette of this paper, many nestcam streaming services now offer viewers the ability to switch between various nestcams aimed at the same nestbox. Usually, one of the nestcams will provide an overhead perspective, allowing for close inspection of their intimate lives, while additional nestcams tend to offer background images of peregrines in their urban settings (Figure 5). For Nigel, 'having the image of the broader environment just gives you a bigger perspective on where the birds are,' which, according to Maria, helps 'increase public awareness about urban wildlife.' Indeed, images like those depicted in Figure 5a encourage viewers to rethink their local urban environment. Stuart told us: 'cities are much better for wildlife than I thought they were. I think that's probably the truth after seeing the success of an apex predator ... But now I think it's a nice space for wildlife; this facet to it that I never saw before nestcams.' Urban peregrines (and wildlife more broadly) are thus made knowable to diverse publics through being digitised via nestcams, which can be accessed by anyone, anywhere in the world with internet access.

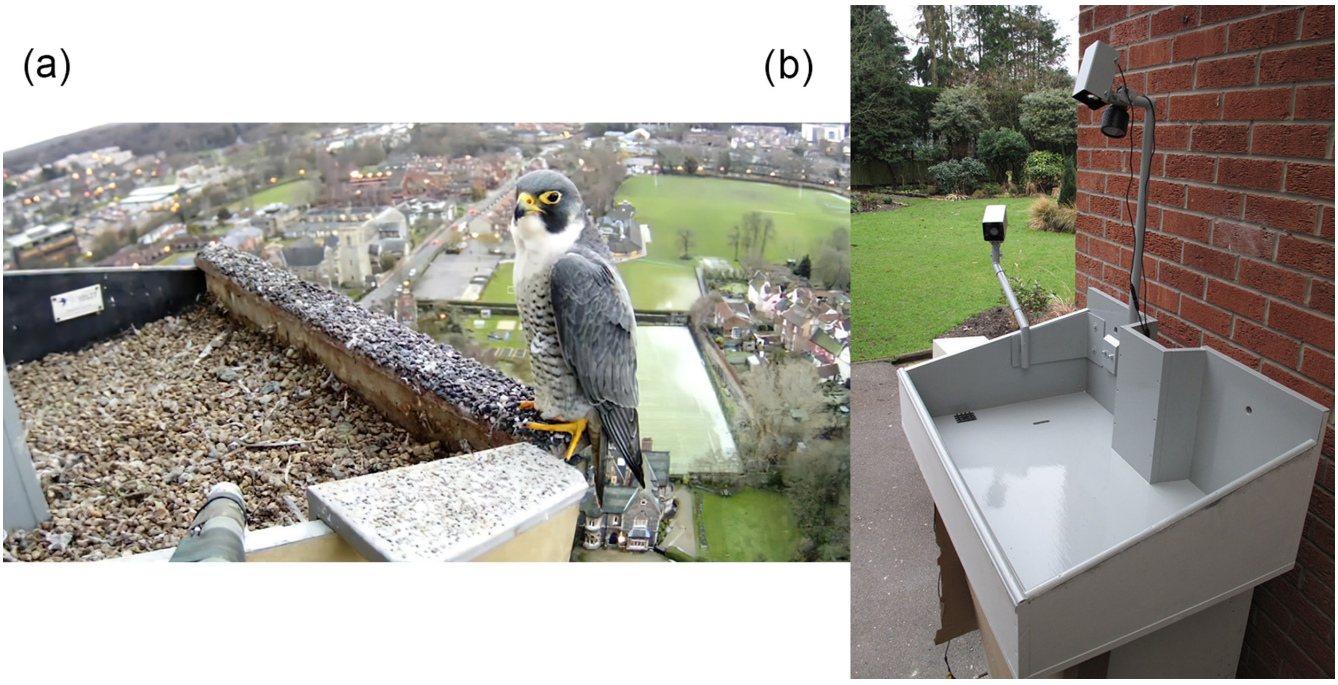

FIGURE 5 (a) A peregrine on the spire of Norwich Cathedral, taken from the nestcam offering views of the wider urban environment. (b) The set-up of these nestcams before the custom built nestbox was erected and filled with substrate to encourage peregrine nesting. *Source*: (a) Photograph reproduced courtesy of the Hawk and Owl Trust and Norwich Cathedral. (b) Photograph by David Gittens and reproduced with permission.

4 | PUBLICS AND CO-PRODUCING THE DIGITAL PEREGRINE

Birdwatching (or birding) is a complex social practice, taking place in a variety of forms across cultural contexts (Wilkinson et al., 2014). Digital birdwatching via nestcams is a distinct form of birding practice. Livestreaming from Sussex Heights, writes naturalist Ed Drewitt, was 'the very beginning of many people's enjoyment, fascination, and hobby (even bordering on obsession!) of watching peregrines online from nests around the globe' (2014, p. 118). Nestcams allow humans to engage with urban wildlife and are 'a great way of enabling others to enjoy and love the birds' (Drewitt, 2014, p. 119). The digital peregrine concerns 'the emergence of new socio-technical formations' (Jasanoff, 2004, p. 15). Here, we examine how the digital peregrine is co-produced by publics who engage with livestreaming technologies and ask how these socio-technical formations may: (i) enable broader publics to access wildlife conservation; and (ii) result in alternative visions of peregrine falcons.

4.1 | Breaking down barriers

Although online traffic to streaming platforms intensified significantly during the COVID-19 pandemic in 2020, our survey results suggest that peregrine nestcams had a longstanding following which preceded the pandemic. Thirty-five percent of respondents had been watching for over five years, and 74% had been watching before the pandemic. Sixty-four percent watched nestcams daily, and 88% watched multiple times per week.

The diversity of nestcam birding is evidenced by our survey. Of survey respondents, 68% identified as female, 29% as male, and 3% as non-binary, reflecting the conclusions of Sunwoo Lee and colleagues who show that birdwatching practice is appreciably gendered: women are more likely to consider birdwatching 'as a form of personal enrichment, enjoyment, satisfaction, and recreation,' while for men, it is more competitive and involves 'going outdoors' (2015, p. 47). A plethora of reasons were given for watching nestcams. Despite this heterogeneity, respondents experienced similar affective responses to peregrines, tending to frame them as sources of entertainment, comfort, or fascination. Part of the digital peregrine's charisma is related to specific assemblages of mediation and perspectives offered through nestcam lenses; viewers reported strong affinities to wider shots offering a broader vantage over urban habitats.

Nestcams share characteristics with 'slow television' (Jørgensen, 2014). Despite moments of obvious drama, people are drawn to the calmness and predictability of peregrine livestreams, as well as the opportunity to attune to other animals' atmospheres (see Lorimer et al., 2019). Ringo commented: 'it's the ultimate slow TV, int'it, peregrine cameras … it's about connections with landscape and wild spaces.' For Nigel, the peregrines were good at following the script: 'they're unlike any other bird of prey; they're very reliable, so nine times out of ten you'll see them, they're predictable.' Clive remarked that 'webcams bring the birds closer to people who just want to watch them.' He reflected on peregrine observation in the early 1990s as an arduous task: 'maybe an hour's drive, twenty minutes' walk, set up a telescope, you're subjected to the worst weather conditions—sweltering heat and mosquitos, or pouring rain and wind—basically just chancing your luck to see peregrines from a distance.' The reliability of digital peregrines made interspecies connection more accessible to broader publics. Clive told us that 'now, y'know—bang!—within twenty minutes I can look in, I dunno, twenty different peregrine nests.'

Digitisation offers many opportunities for public outreach. 'In the UK, which is an urbanised country, most people might not realise their direct connection to wildlife, they can't discover it very easily,' Ringo explained. 'With peregrines on a webcam, you can gain interest quite easily; the cameras have the ability to break down barriers. Barriers to wildlife can be quite high, and to really get into wildlife is tough for many … but the key to broader public engagement has definitely been the webcams.' Eugene—an ecologist who runs outreach projects across the West Midlands—reflected that conservation felt inaccessible to him growing up in an immigrant family in Birmingham. He saw conservation as 'white, middle-class, and middle-aged,' which is enough to put many people off engagement. Eugene noted that his public engagements were often unplanned, especially with 'kids mucking about' who are intrigued by technologies like telescopes that allow them to observe predation, which is commonly exciting for new audiences. He added, 'if you get to show them the birds, all of a sudden, they're engaged, they're excited, wanting to see the birds again … the webcams are a real part of that, especially in the digital age when people spend so much time behind the screen, or on their devices.'

Maria also said that nestcams appeal to many deterred by the 'male-oriented and middle-aged' demographics of birdwatching:

> Technology is the ultimate hook for getting a new audience. My friend runs the Facebook page for a nestcam. The group members aren't necessarily birders. Lots of them like peregrines because there's a local connection, they feel like 'oh, that's my bird on a cathedral where I live', so you get that emotional bond. That's a whole new audience the nestcams have created.

Survey respondents reflected on the value of nestcams for generating alternative visions of their own cities, making them aware of the possibility of conviviality with charismatic wildlife in urban space. Indeed, nestcams are popular worldwide, in countless cities, including Barcelona, Melbourne, and Chicago. People frequently watch nestcams from locations, and emotional bonds can span impressive distances. Stuart even told us about a visitor showing up at Norwich Cathedral's peregrine viewing point who'd travelled from Tasmania to see the peregrines in person after following their intimate lives online.

In the ecological vernacular, the peregrine falcon has long been described as a cosmopolitan species (Drewitt, 2014; Molard et al., 2007), meaning a species whose range extends across habitat types around the world. However, through widespread digitisation, the peregrine has also become cosmopolitan in the sense familiar to human geographers and anthropologists. Following the 'cosmopolitics' of Stengers (2003a, 2003b), Barua presents more-than-human cosmopolitanism as a frame to elucidate the roles 'nonhuman entities and animals' play in 'forging global connections across difference' (2014, p. 560). The digital peregrine has thus become a cosmopolitan animal in this dual sense, available to encounters anywhere in the world with an internet connection.

4.2 | Warning: Graphic content

Not only are people attached to nestcams due to their specific geographical location, but people are also drawn to form close attachments with individual birds.[7] Sometimes, the realities of predation and peregrine mortality can be tough on attached publics. When logging into the nestcam streamed live from Nottingham Trent University's Newton Building, viewers are met with the following message:

> WARNING: These webcams show live footage of wild peregrine falcons. Please understand that at times this may include images that you might find disturbing.

Although usually viewers will see what Rachael described as 'peregrines doing absolutely nothing for most of their time,' they can be shocked to see a feral pigeon decapitated from the comfort of their homes. Among research participants, the death of feral pigeons caused little outcry. Yet the killing of more charismatic birds can provoke different reactions. As Kevin explained, 'there are people who can't cope with the idea that there are predators out there. For instance, one time they brought in a great spotted woodpecker, and someone complained to the cathedral.... We've had similar complaints when they'd eaten a budgie.' Such attitudes about individual species are not arbitrary, though. Barua (2021) shows that peregrine predation of parakeets in London is viewed positively or negatively depending on whether or not individuals think parakeets belong in London, or whether they think they're 'exotic', 'invasive', or 'alien' species—labels which are often racially coded. Nevertheless, nestcams offer a graphic and immediate insight into predation, rendering it more real than an abstract going-on above the rooftops (Pitas, 2022).

Nestcam footage also includes situations where the wellbeing of peregrines appears to be at risk. It is not uncommon for many raptor chicks to die before fledging. Kevin said that 'nestcams bring all this into the living room, and some of this stuff can be hard viewing.' It can be difficult to manage public responses to this: 'I just spend a lot of my time explaining death to people ... the public can get really attached to the birds and get very upset if things go wrong.' A way many nestcams seek to reduce this tension is by avoiding naming the chicks, according to Kevin. 'They say to me, can we name them? And I say well, you can if you want, but if you do that, it'll be Peter who's died won't it? Instead of P7 or Z3.' Some nestcam managers spoke of extreme responses to imagery that certain viewers found upsetting. Fraser, for instance, explained that one year, while removing the chicks from their nest for ringing, a nestcam observer in Germany 'managed to get hold of the police in Brighton who turned up in the lift motor room of Sussex Heights.' Such instances illustrate the interpersonal connections afforded through digitisation, which carry material consequences for wildlife conservation. Research suggests that felt connections to species and individuals positively implicates pro-conservation sentiment and behaviour in publics (e.g., Howell et al., 2019; Skibins & Powell, 2013).

Nestcams are thus what Ike Kamphof refers to as 'media of connection', working across affective registers and ethical frames 'to get users involved, personally and intimately, in the lives of animals' (2011, p. 260). The intimacies of peregrine lives are captured and transmitted on screens, then consumed and contextualised in the setting of the human domus. Many of our participants, despite warning against becoming over-attached to individual birds, were frequently unable to abide by their own rule—a common phenomenon among those who practice natural history. Stuart said: 'I try to treat them as wild animals and not to have favourites. But I wouldn't be human if I could actually do that.' Although Kamphof calls this 'digital domestication', we consider it 'digital enclosure'—animals are caught on screen, yet remain wild. The process of attunement is one way only. Nestcams have produced an animal with different cultural resonances; a digital peregrine.

5 | THE LIMITS TO DIGITISATION

The digital peregrine is a socio-technological formation co-produced by digital technologies and viewing publics. Peregrine digitisation involves a series of continual conversions from the 'analogue peregrine' to the digital peregrine encountered on the screen, which take place across several material sites (Degen et al., 2015; Rose, 2015). The digital peregrine is thus multiple, emergent, and transient, and hence also subjective and partial. But what is lost in translation and transmission between the corporeal and digital peregrine? Which aspects of peregrine lives escape digitisation, and how does this engender alternative visions of peregrines?

Peregrine enthusiasts are enchanted by the raptor's ability to confound imaginations about what is naturally possible. The peregrine's stoop—when it adopts a bullet-like form and dives at the fastest speeds ever produced by evolution—has been described by Ed Drewitt as 'mindboggling' (2014, p. 21). He writes: 'when [a peregrine] is in stoop dive it drops through the air with speed, grace, and perfection' (2014, p. 20). The finesse of peregrine stoops has attracted falconers for millennia (Ratcliffe, 1980). However, when peregrines go hunting, they escape the panoptic nestcam gaze. Hunting behaviours like the stoop evade the so-called 'domesticating'—or enclosing—tendencies of technology. As such, there remains an intractable wildness to peregrines, uncaptured by nestcam digitisation.

The alluring quality of peregrines, for Rachel, is their predation behaviour: 'there's nothing more exciting than seeing a peregrine hunt, which you can't see from a webcam.' Aerial food passes—when the hunting peregrine throws prey mid-flight to the peregrine guarding the eggs—were often cited as 'magical' moments by participants. Such moments, however, evade the nestcam gaze. 'Seeing peregrines in person is so fun, because you see so much more action,' noted Maria. 'If you're lucky you'll see an aerial food pass. Like, to see that, is insane. With the camera all you'll see is ... 'yeah, alright, she's leaving the box now'.' The excitement gleaned from observing urban predation, for both Rachel and Maria, is not achievable through nestcam digitisation. Others are drawn, and become attached, to individual chicks and their development, watching with anticipation as they prepare to fledge. For a few weeks, juveniles take small flights, increasing in frequency and duration before eventually departing the nestbox. During this period they return to viewers' screens, but afterwards they are quickly gone. What happens while they disperse and establish their own nesting sites returns the peregrine to the imagination once again.

The fact that the digital peregrine is only part of a wider story is integral to its charisma. Eugene expressed his hopes that peregrines wouldn't become so present that they went the way of the red kite, because 'people have fallen out of their honeymoon period with them.' Clive made a similar remark: 'I don't want peregrines to become so common that they lose their special features, their allure, their wildness.' Among some, there is a fear of oversaturation through the mass digitisation of peregrines and other wildlife. As they become accessible 24/7, might people get bored with them, diminishing the potentials of digital conviviality? We do not have an answer to this question. Yet the diverse reasons people watch peregrines, and keep coming back, suggest not. Unlike red kites circling above motorways, peregrines do not lend themselves to accidental encounters. Those tuning into nestcams actively choose to do so, again and again.

For practitioners working closely with nestcams, there is something special in digitisation's inadequacies. The digital peregrine remains partial, which draws many people to seek out encounters with peregrines 'in the flesh' following digital encounters. For such people, wild peregrines are always made sense of through a combination of physical and online encounters: they are hybrid and more-than-real. Rose argued that hybrids 'transgress and displace boundaries between binary divisions and in doing so produce something ontologically new' (2000, p. 364). For Adriana de Souza e Silva, hybrid spaces blur the borders between physical and digital space, forcing a recognition that 'the digital has never actually been separated from the physical' (2006, p. 274).

Many participants involved in peregrine conservation used a mixture of nestcams and in-person observation in outreach projects, noting that events like fledging and food passes can only be seen from an in-person viewing point. Stuart

and Maria both spend countless hours every summer volunteering in an observation tent pitched on the green facing Norwich cathedral (Figure 6). Here, they show the nestcam livestream and share telescopes and binoculars with eager visitors while explaining their conservation mission. Charlotte Chambers (2007) raises an interesting question: how are visual technologies such as binoculars and telescopes any different from sophisticated audiovisual equipment in mediating more-than-human encounters? Indeed, these 'traditional' modes of mediation have produced specific ways of seeing wildlife for centuries. As Donna Haraway argued, 'there are only highly specific visual possibilities, each with a wonderfully detailed, active, partial way of organising worlds' (1988, p. 583). By combining nestcam and telescope perspectives on peregrines, 'you can see a lot more,' noted Maria. By diversifying the technologies used to observe the peregrines, then, these partial perspectives multiply and overlap.

Fraser had worked in a similar marquee in Chichester, where visitors could 'see the bird live through a telescope coming in with prey, land in the turret, then turn their heads to look at a big TV screen that we were livestreaming to.' This blended observational experience, for Fraser, allowed visitors to 'actually visualise what's going on, how high up it is, and how big the bird is, whereas on a webcam you could be watching peregrines here or you could be watching big cats in Africa or something. It's all very exciting but it's not quite the same.' Such hybrid spaces create opportunities for engaging publics with peregrines who may not have engaged with them otherwise. In creating these spaces, conservationists are able to encourage people to contextualise the raptors in their ecological, cultural, and technological milieus. The peregrine's hybridity, however, is not dependent on the spatiotemporal coincidence of the physical and digital encounter. Observation tents just bring the peregrine's multiplicity into sharp focus due to the spatial proximity of peregrines, observers, and screens. Furthermore, after viewing peregrines via nestcams, several participants were moved to observe them in-person, demonstrating that digital technologies, under certain circumstances, encourage people to experience nature directly (see Tosa et al., 2021).

Digital animals in mediated networks complicate the binary between digital and physical space (Berland, 2019; Stinson, 2017). McLean's (2020) term 'more-than-real' avoids the tendency of terms like 'virtual' to diminish the importance of encounters that occur in digital spaces. Following McLean, then, the digital peregrine is not *just a representation* of an actual peregrine. Despite being partial, the digital peregrine is not less-than-actual, a diminished form of a 'real'

FIGURE 6 Peregrine observation point on the green outside Norwich Cathedral.
Source: Photograph by David Gittens. Reproduced with permission.

peregrine; it is more-than-real, an encounterable entity which is moored to the actual corporeal peregrine. As such, encounters with digital peregrines engender a distinct set of affects from those associated with corporeal peregrines. For instance, the up-close-and-personal view afforded by nestcams provides access to intimate moments in peregrines' lives that emphasise cuteness and vulnerability over fierceness and magnificence, which are more commonly associated with corporeal peregrine encounters. It is not uncommon for viewers to experience awkwardness and a sense they are invading the private lives of peregrines. These affects are distinct from those produced through corporeal peregrine encounters worthy of sustained attention due to their potential for inciting meaningful responses from viewers. Thus, rather than opting for *either* digital *or* corporeal peregrines, a more-than-real frame enables relations with both corporeal and digital peregrines to be taken seriously in conjunction. By considering digital peregrines as 'more-than-real', we have attended to the 'ontologically new' (Rose, 2000) aspects of digital peregrines and their unique affordances.

6 | CONCLUSIONS

Peregrine resurgence since the 1990s is historically entangled with developing digital technologies. The revenant peregrine, however, is not identical to the one that was lost. Contemporary peregrines have moved from rural into urban areas *en masse*, and many are now digitised and livestreamed 24-hours-a-day. They have moved from absence to ubiquitous presence in only three decades: once whispered about, now our neighbours; once kept secret for their protection, now made public for their protection. Our technonatural history of peregrine resurgence documents how nestcams have transformed who relates, and how people relate, to peregrines in the UK.

Both urbanised and digitised, peregrines have become cosmopolitan animals, emblematic species for contemporary conservation. When the first peregrine nestcam went live in Brighton in 1999, its audience members were predominantly in Germany. Watching peregrine nestcams was popular in Germany before it was popular in the UK. According to Fraser, there existed a population of German livestreamed animal enthusiasts who sought out digital animals from around the world. German birders observed the intimate lives of British peregrines 24-hours-a-day online. Their cosmopolitanism is thus ecological *and* cultural: they occupy habitats worldwide, while being digitally mediated to diverse global publics who respond to them in several ways.

Compared to corporeal peregrines, the digital peregrine has an experientially distinct set of affects and affordances. Instead of lamenting these digital encounters as diminished versions of actual encounters, we highlight the important role the digital peregrine plays in fostering conviviality. Digital peregrines broaden access to wildlife, attracting both seasoned and first-time birders. Indeed, the conservation outreach potential of peregrine digitisation is enormous. It is unclear, however, whether such strategies involving digitisation would be effective for other, less charismatic species. The specifics of peregrine history, the ease with which they are digitised, and their general popularity each contributed to the success of the digital peregrine and its corporeal counterpart. Furthermore, the communities of care and conservation that have flourished around the digital peregrine are cause for celebration. In the peregrine's case, digital technologies create opportunities for urban conviviality, challenging prominent tropes in conservation that technologies inherently disengage humans from other species.

By treating nestcams as sites of encounter worthy of attention, we demonstrate that meaningful human–animal relations can occur online. In doing so, we disrupt distinctions between 'actual' and 'digital' space, favouring a more-than-real approach that permits critical appraisal of the potential for digital technologies to foster convivial and care-full more-than-human relationships. We urge geographers to examine technonatural histories in other contexts. In deploying technonatural history as both method and theoretical frame, researchers can articulate, examine, and historically situate increasingly digitised more-than-human worlds, or technonatures. This involves unsettling purist historical formulations of natural history, accounting for the role of technologies in developing species-specific ecological and ethological knowledge, and detailing the way they recalibrate practices of observation.

We stated that perceptions of rarity drove initial interest in peregrine nestcams, but as their resurgence continues and rarity decreases, what drives continued interest in these livestreamed birds of prey? We suggest three factors. First, given most nestcams are in urban spaces, there remains an allure to see these elusive charismatic predators in nominally human spaces. Indeed, their charisma is entangled with the urban landscape. Second, nestcams produce specific but diverse affects—from excitement to relaxation. It is possible to 'have the peregrines on in the background' while doing other activities, like we have while writing this paper; but they can also be observed with anticipation and excitement during hatching or fledging season. And third, nestcams are only beginning to be realised for their epistemic, knowledge-generating potential, which we will explore in future work.

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DATA AVAILABILITY STATEMENT

For reasons of ethics and privacy, data are not shared.

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ENDNOTES

[1] There are at least 50 nestcams in the UK (shown in Figure 1), on which 504,000 minutes are livestreamed weekly.

[2] These groups are not mutually exclusive. Research participants are anonymised.

[3] Keywords used: 'peregrine falcon'; 'peregrine'; 'falcon'; 'webcam'; 'nestcam'; 'camera'; 'UK'; 'nest'; 'livestream'; 'stream.' These figures contain an unavoidable sampling bias—the most popular nestcams have likely been active longer, so had more opportunities to gain followers. The exact number of UK nestcams is unknown due to privacy issues on many streams, and a quickly changing environment.

[4] The peregrine is protected under Schedule 1 of the Wildlife and Countryside Act 1981, meaning 'it is a criminal offence to intentionally or recklessly kill, injure or take a peregrine … to take, damage or destroy the nest of a wild bird while it is in use or being built or to take or destroy the eggs' (London Peregrine Partnership, 2021, n.p.).

[5] Sussex Heights was the world's second peregrine nestcam, the first being on the Sun Life centre in Toronto (Drewitt, 2014).

[6] A 'behind-the-scenes' blog explaining the establishment and maintenance of the Loch Arkaig nestcam: https://www.woodlandtrust.org.uk/trees-woods-and-wildlife/osprey-cam/behind-the-scenes/.

[7] Evidenced by the heartfelt obituary for Princess, a peregrine from Manitoba, 'The Passing of a Grand Old Lady': http://www.species-at-risk.mb.ca/pefa/blog/2022/01/the-passing-of-a-grand-old-lady/.

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