Article

Society and Space

EPD: Society and Space
2024, Vol. 42(2) 254–274


Article reuse guidelines:
sagepub.com/journals-permissions
DOI: 10.1177/02637758241229896
journals.sagepub.com/home/epd
Sage

Keeping time with digital technologies: From real-time environments to forest futurisms

Kate Lewis Hood
Royal Holloway University of London, UK

Jennifer Gabrys
University of Cambridge, UK

Abstract

Forests are zones of multiple temporalities. They keep time and are constituted through time-keeping practices. Digital technologies of environmental monitoring and management increasingly organise forest temporalities. This article considers how emerging techno-temporalities measure, pace, and transform forest worlds while reproducing and reconfiguring longer durations of colonial and capitalist technologies. We draw together scholarship on political forests, digital media temporalities, and anti-colonial and Indigenous thinking to analyse the politics of time that materialise through digital technologies and shape what forest pasts, presents, and futures are sensible and possible. In particular, we trace the socio-technical production of the 'real-time' as a temporal register of experiencing, knowing, and governing forest environments. Analysing a real-time deforestation alert system in the Amazon, we consider how these temporalities valorise immediate, continuous forest data that can be mobilised for understanding and protecting forests, while simultaneously glossing over durational colonial and capitalist framings of forests that rely on dispossession, extraction, and enclosure. The second half of the article turns to Indigenous futurisms and artistic and socio-political uses of digital platforms that rework forest temporalities. By analysing these multiple and sometimes contradictory temporalities, we suggest that these practices and interventions can challenge dominant timelines and their inequities through pluralistic and redistributive configurations of temporality, land, and data sovereignty.

Keywords

Digital technology, temporality, forests, real-time, futurisms

Corresponding author:
Jennifer Gabrys, University of Cambridge, Free School Lane, Cambridge, England CB2 1TN, UK.
Email: jg899@cam.ac.uk

Introduction

> En tiempos de crisis climática, el futuro es un territorio a defender.
> In times of climate crisis, the future is a territory to defend.
> (Futuros Indígenas, 2021)

Asserting that 'the future is a territory to defend', the Futuros Indígenas Manifesto highlights and contests the ways that certain futures are made at the expense of others. After centuries of colonial and capitalist 'extermínio, ecocídio e genocídio' [extermination, ecocide and genocide] and 'la catástrofe del progreso [y] del desarrollo' [the catastrophe of progress and development] for Indigenous and Afro-descendent peoples and lands in Milpamérica/Latin America, time does not simply flow. Instead, *how* time is understood and practised shapes what is imaginable and possible in plural 'times of climate crisis'. Neither is the authors' framing of the future as a territory merely metaphorical. Whereas in dominant climate discourses and technologies the future becomes a singular site of urgency and management, Futuros Indígenas emphasise that time and futurity are made and unmade through specific environments and more-than-human relations, shaped by ongoing histories of dispossession and extraction, and colonial and capitalist technologies of space and time. In this context, the Manifesto asserts the need to defend the future not just from the wreckage of colonialism, capitalism, and ecocide, but also from the ongoing colonial territorialisation of what other worlds could be held open, lived, and made possible.

In global climate change discourse, forests are positioned as crucial for addressing climate and biodiversity crisis and protecting human and nonhuman futures, often because of their multi-temporal processes of carbon cycling and storage and complex ecosystem interactions (FAO and UNEP, 2020). Digital technologies are increasingly important in these forest futures, developed and deployed as tools of environmental sensing, monitoring and management (Gabrys, 2020). From automated tree-planting machines and data platforms tracking forest restoration (Urzedo et al., 2022), to drones used for counter-mapping forest territories (Paneque-Gálvez et al., 2017; Radjawali et al., 2017), such technologies do not merely measure forest processes but also actively shape forest knowledges and governance practices in the context of environmental change. More recently, a growing emphasis on 'real-time' and 'near real-time' technologies has emerged, variously facilitating ongoing monitoring of forest processes and faster responses to deforestation and environmental degradation (Global Forest Watch, 2023; Zweifel et al., 2023). However, the conceptions of time underpinning these 'real-time' technologies remain under-examined in terms of how they not only measure but also pace and transform unevenly constituted forest worlds.

In this context, this article asks: 1) How are time and technology co-constituted in increasingly digitalised forest environments? 2) How do the temporalities of 'real-time' and 'near real-time' digital technologies shape the material and epistemic conditions of forest environments and lifeways? 3) How do artistic and socio-political practices generate and mobilise other temporalities of forest memory, presence, and futurity? To answer these questions, which are situated in the context of the Smart Forests research project on the socio-political aspects of digital technologies in forest environments, we undertook literature surveys using scholarly databases, search engines, and social media; analysed project websites and other publicly available discourses; and conducted semi-structured interviews with selected practitioners. Noticing that the relationship between temporality and coloniality was rarely part of discussions of emerging digital forest technologies, we turned to artistic practices alongside technoscientific and environmental practices from diverse forest geographies.

This approach, engaged in dialogue with methodologies from the environmental humanities and Indigenous futurisms, highlighted different methods of sensing, measuring, reimagining, and transforming forest temporalities that also call attention to the stakes of these transformations. Through this approach, we consider how digital technologies – particularly those oriented around and producing the 'real-time' – can foreshorten temporalities and socio-political engagements. What is at stake in this foreshortening is overlooking or overwriting accumulated environmental violences, which in turn can reproduce existing dynamics of power in presupposing and limiting future trajectories.

The first half of the article examines real-time forests as socio-technical productions that attempt to calibrate different environmental monitoring technologies – from remote sensing infrastructures to co-designed community monitoring apps – to facilitate the protection of forest environments. Analysing a near real-time monitoring project in the Peruvian Amazon, we consider how real-time monitoring technologies operate within colonial and capitalist organisations of time, which can complicate their ability to challenge dispossession, extraction, and deforestation amongst complex forest assemblages comprised of multiple knowledges, sovereignties, and relations. The second half of the article turns to Indigenous futurisms (Dillon, 2012) and artistic practices using digital platforms to remember and assemble different temporalities of forest knowledge-making and relation. Attending to two platforms – one engaged with Inga territory in Colombia and the other with the forested geographies of South and Southeast Asia – we consider how interconnected artistic, political, and technological practices contest techno-temporal paradigms oriented around resource-intensive innovation, institutionalised expertise, and ongoing access to Indigenous land, knowledges, and data. Such practices configure and perform multi-temporal, intergenerational, and multi-perspectival ways of sensing forest durations and transformations, while reworking dominant forest temporalities.

In addressing diverse (post-, neo-, and settler) colonial and Indigenous forest geographies, we are mindful of important interventions by Indigenous scholars that highlight how academic scholarship – including work with anti-colonial and decolonising aims – often structurally and institutionally reproduces Euro-Western knowledge paradigms and extractive approaches to Indigenous knowledges (De Leeuw and Hunt, 2018; Loseto et al., 2020; Watts, 2013). Assumed access to Indigenous digital practices and data (Carroll et al., 2020, 2021) and to environmental knowledges and data in the context of climate change (Williamson et al., 2023) can also constitute forms of extraction that maintain settler and white supremacist futurities. However, Indigenous technological and knowledge practices also incorporate forms of refusal and resurgence that exceed dominant institutional modes of legibility (A. Simpson, 2014; L. Simpson, 2017). By examining the temporal structures and framings that organise and are organised by real-time forest technologies, we aim to offer an analysis of the real-time in relation to durational operations of coloniality in the context of environmental change. Anti-colonial and Indigenous knowledges highlight how dominant conceptions of time operate to overwrite other epistemologies and maintain formations of power, while also offering theories and practices for configuring time and temporal relationships differently (Curley and Smith, 2023). When 'the future is a territory to defend' (Futuros Indígenas, 2021), we contend that a temporal analysis of *how* forests are technologically paced, measured, and experienced brings attention to patterns, contradictions, and slippages in the ways that forest techno-temporalities are co-produced, maintained, contested, and reimagined. We also attend to socio-political possibilities such slippages might open up in transforming the uneven constitution of forest knowledges and lifeways and configuring other, pluriversal trajectories (de la Cadena, 2010) and frequencies of forest relation.

Real-time forests

'Ever wanted to hear a forest in real-time?', asks the advert for the Rainforest Connection app, which allows listeners to tune in remotely to acoustic monitoring systems designed to detect illegal logging and poaching activity in forest locations (Rainforest Connection, 2023). Global Forest Watch, an online platform developed by the World Resources Institute with a wide range of global partners, claims that it 'allows anyone to access near real-time information about where and how forests are changing around the world', combining multiple datasets to generate geospatial data visualisations and deforestation alerts (Global Forest Watch, 2023). These are prominent examples from a growing number of real-time and near real-time forest monitoring technologies used across a range of contexts, from forest protection and conservation (Musinsky et al., 2018; Pratihast et al., 2016), to ecosystem science (Campbell et al., 2021), to Indigenous community monitoring practices (Slough et al., 2021). But how does the real-time operate within longer and pluralistic temporalities constituting forest environments, subjects, and relations?

Forests have been rendered as temporal objects in the establishment and maintenance of colonial logics that persist in technoscientific approaches to addressing environmental change. The making of scientific forestry involved the institutionalised regulation and quantification of territorial forests through technologies of measurement and calculation, producing 'empires of forestry' (Peluso and Vandergeest, 2006a, 2006b) across extended timescales of management and extraction. As Nancy Lee Peluso and Peter Vandergeest (2001) have elaborated in the context of Southeast Asia, 'political forests', made through bumpy, contested processes of colonial state territorialisation, are not only spatial but also temporal claims: 'Forests take many years to grow and thus tie up large territories for their production or protection' (Peluso and Vandergeest, 2001: 764). These processes of producing networked colonial geographies also often involved the regulation or removal of Indigenous people living in and with the forests. This combination of extended spatio-temporal claims on forest land with temporal constructions of technological progress, innovation, and advancement is reproduced in postcolonial state contexts (Peluso and Vandergeest, 2011) and in environmentalism and conservation (Barton, 2002). In more recent forms of 'green neoliberalism' (Devine and Baca, 2020; Peluso and Vandergeest, 2020), forest temporalities are retooled by a range of state and non-state actors, from private startups planting fast-growing tree species for marketised carbon offsetting projects (Urzedo et al., 2022), to local communities whose forest interactions are configured through (often state- and NGO-mediated) participation in international forest frameworks oriented around carbon metrics, such as REDD+ (Asiyanbi et al., 2019). Across these divergent examples, time is an important component in the rendering of forests themselves as technologies for the attempted management of environmental change (Gabrys, 2020), and in the reproduction of uneven forest geographies and relations.

Digital operations and practices facilitating the datafication, automation and optimisation of forest environments produce temporalities oriented around newness, liveness, linearity, accumulation, simultaneity, and efficiency (Gabrys et al., 2022). In this context, the real-time has emerged as a technological and temporal paradigm for smart environmental monitoring and regulation (Bakker and Ritts, 2018; Gabrys, 2016). 'Real-time' is a computing term used to describe operations with guaranteed response times, often fast enough to affect the environments in which they occur (Shin and Ramanathan, 1994). 'Near real-time' allows for delays, which can range from seconds to days depending on the operation. Critical studies of the real-time in digital media scholarship largely focus on social media rather than environmental contexts, but usefully highlight how the real-time does not just

exist *in* the world, but rather is socio-technically constructed as 'realtimeness' (Weltevrede et al., 2014). Realtimeness emphasises speed, immediacy, instantaneity, and a sense of unmediated encounter, and is shaped by specific devices, infrastructures, and practices that 'pace' the interplay between computation and experience in the temporal unfolding of data (Lupinacci, 2022; Wajcman, 2015 ; Weltevrede et al., 2014). Realtimeness increasingly organises 'digital ecologies' (Turnbull et al., 2023), from forest monitoring networks and data infrastructures (Gabrys, 2022; Zweifel et al., 2023) to mediated human–nonhuman encounters through livestreams and mobile apps (Kamphof, 2013; Westerlaken et al., 2023).

In deforestation monitoring systems, near-realtimeness emerges through large-scale, well-funded projects and data infrastructures using satellite and other remote sensing technologies. These systems aim to be accessible in near real-time to a range of users through geospatial data visualisations, monthly reports, and deforestation alerts that can be received via email or mobile apps. Timing and 'temporal resolution' (the frequency of imagery) are crucial to the ongoing development of deforestation monitoring systems (Finer et al., 2018). In practice, the 'near real-time' often refers to satellite and remote sensing data up to one month past. Global Forest Watch, for example, uses the University of Maryland's Global Land Analysis and Discovery datasets, which provide updated medium-resolution satellite imagery around every eight days (if there is no cloud cover), and the University of Wageningen's Radar for Detecting Deforestation datasets, whose imagery is updated every 6 to 12 days. In Brazil, the nonprofit research institute Imazon draws on monthly satellite data from a range of Brazilian initiatives for the PrevisIA platform, which not only monitors present and past forest change but also uses AI to predict areas where deforestation is likely to occur in the following year (Souza et al., 2023) . Existing analysis suggests that near real-time monitoring systems such as Global Forest Watch may have contributed to a decrease in deforestation in some regions, but that their large-scale impacts are unclear (Jamilla, n.d ; Moffette et al., 2021). Other work focuses on specific sequences of action, 'from satellite to intervention' (Finer et al., 2018), through which researchers, policymakers, NGOs, and communities engage real-time environmental data (Gabrys, 2019).

However, this shift towards real-time forests has not been analysed in depth in terms of how the real-time reproduces, optimises or transforms dominant modalities of environmental understanding and governance. As James Miller and Eric Nay (2022) discuss, temporalities of innovation, increased efficiency, and immediate crisis response define a Euro-Western 'techno-ontology' programmed towards colonial conceptions of progress and techno-capitalist fixes, including in emerging 'green' and environmental technologies. As Indigenous scholarship highlights, the often present-oriented and linear temporalities of climate change imaginaries, environmental technologies, and the knowledges and decision-making they facilitate rarely encompass non-Western and more-than-human temporalities, or the durations of colonial ecocide (Awâsis, 2020; Whyte, 2017). In this sense, emphasis on the 'real-time' as the time that matters for forests risks reproducing the 'temporal orientations' – the framings, paces, and scales of time (Rifkin, 2017) – of colonialism and capitalism, while at the same time presencing these temporal orientations as neutral. As Kahnawà:ke Mohawk scholar Audra Simpson (2017: 21) describes, the colonial present is defined by 'purported newness' based on a 'fiction of the presumed neutrality of time itself, demonstrating the dominance of the present by some over others, and the unequal power to define what matters, who matters, what pasts are alive and when they die.' In the next section, we attend to these uneven stakes in the socio-technical production of real-time forests, focusing on a deforestation monitoring and alert system in the Peruvian Amazon.

Alert and delay

Rainforest Alert is a deforestation monitoring programme co-developed by the nonprofit Rainforest Foundation US with Shipibo communities and later the Organización Regional de los Pueblos Indígenas del Oriente (Organization of the Indigenous People of the Eastern Amazon) in Peru. Originally named Información en Acción (Information into Action), Rainforest Alert aimed to make near real-time data accessible and useable for Indigenous communities engaged in forest monitoring, to support efforts to reduce deforestation and illegal agricultural settlement. Over 100,000 hectares of the Peruvian Amazon undergo deforestation each year, reflecting ongoing legacies of twentieth-century development and land title policies that promoted agricultural production and treated forests largely as a subset of agricultural land (Dávalos et al., 2016; Pokorny et al., 2021; Ravikumar et al., 2017).[1] Such policies are themselves legacies of colonial discourses of land improvement and productivity (Sax, 2020). In this context, Rainforest Alert combines technological and economic support with an emphasis on community participation and agency in different forms of forest governance. We explore how realtimeness structures the ways that responses to deforestation 'events' become actionable and measurable, even as this realtimeness is shaped by multiple logistical, technological, and political obstacles. While the programme facilitates community-led conservation and territorial defence, we suggest that its temporal orientations also operate to structure and overwrite a multiplicity of temporalities, and obscure enduring and renewed forms of dispossession, commodification, and extraction.

Rainforest Alert's methodology, summarised (and presumably simplified) in a public video documenting the project's impacts, involves a sequence of steps for community action:

> Step 1: Ensure legal rights to control territory
> Step 2: Monitor with technology
> Step 3: Formalize decision making
> Step 4: Engage government and enforce
> Step 5: Build sustainable economies (Rainforest Foundation US, 2021)

Although presented in a linear sequence, in practice these steps involve complex political processes unfolding across multiple temporalities shaped by (post)colonial land governance, uneven data infrastructures, and technological devices. For example, the first step suggests that a temporal precondition for monitoring to be effective is establishing legal rights to territory, implicitly on the terms of the nation state. However, such a process alone could be indefinite in temporality. As Roger Merino (2021) describes, the Peruvian state has no formal definition for Indigenous territory. Following the Ley de Comunidades Nativas (Law of Native Communities, no. 20653) in 1974, recognised Indigenous communities were granted 'collective ownership' rights over land, and Indigenous political organisations such as AIDESEP (Asociación Interétnica de Desarrollo de la Selva Peruana/Interethnic Association for the Development of the Peruvian Rainforest) began to mobilise around pursuing Native land titles. However, the protection offered by state legislation has been nonlinear and uneven. President Alberto Fujimori's leadership in the 1990s reopened Indigenous forest lands to mining and logging interests, and the legacies of neoliberal policies form the context for ongoing forest governance (Monterroso et al., 2017).[2] Under current legislation (Law no. 29763, 2011), collective ownership rights do not include forest or subsoil resources, which are managed by the state in the 'national interest'. Rights to forest resources are temporary, governed by 40-year forest and agroforestry concessions and usufruct rights. In this context, using state legal infrastructures has led to

limited outcomes for Indigenous peoples claiming territorial rights, and several Indigenous organisations, including the Wampis Nation and the Coordinadora Regional de los Pueblos Indígenas de San Lorenzo (Regional Coordinator of Indigenous Peoples of San Lorenzo/CORPI), are working towards more autonomous models of governance based on 'integral territory' and nation-to-nation relationships with the Peruvian state (Merino, 2021). Under the current national legislative model, passing step 1 could be a lengthy process and fail to lead to the forms of self-determination, forest and territorial governance that some Indigenous communities are articulating and demanding.

The state claim on forests as national resources (for protection or production) is also a claim on time. National actors mobilise the temporalities of forest ecosystems to justify the long-term management of these ecologically important spaces, an approach continuous with colonial processes of dispossession (Peluso and Vandergeest, 2001). In addition, locating forests within the 'national interest' seeks to assert a 'shared present' (Rifkin, 2017) in which Indigenous peoples are enfolded within the nation state and its 'institutions, interests, and imperatives' (Rifkin, 2017: viii). This shared present overwrites Indigenous pasts of forest relation, dispossession, and genocide, while the future secured in the national interest naturalises business-as-usual capitalism alongside forms of national, corporate, and global environmental citizenship (Merino and Gustafsson, 2021). Legal and extralegal contestations over space are contestations over Indigenous pasts, presents, and futures. These forest spaces are lived and transformed unevenly along multiple trajectories by state and non-state actors, including transnational corporations, environmental enforcement agencies, small-scale farmers, and Indigenous people, producing overlapping land rights and environmental practices (Merino and Chinchay, 2022; Ravikumar et al., 2017), and, we add, temporalities.

How does the realtimeness constructed through deforestation alert systems such as Rainforest Alert reinforce or enable Indigenous interventions in dominant formations and trajectories of forest governance? As discussed in an interview with Tom Bewick, former Peru Country Director for Rainforest Foundation US, the realtimeness of Rainforest Alert practically involved multiple, sometimes overlapping or contradictory temporalities (Bewick, 2023; see also a podcast version of the interview in Bewick et al., 2024). In addition to the one-to-two-week lag in the near real-time satellite data, the Rainforest Foundation US field team and members of ORPIO had to circulate data to communities with limited internet connectivity and network infrastructure. As Bewick described, the team downloaded deforestation data points from Global Forest Watch or Peru's Geobosques platform onto Locus (a mobile app designed for outdoor sports that allows maps to be accessed offline). They then collated and physically delivered data to communities on SD cards or USB sticks from an ORPIO-run regional data hub. Once communities had received the information, trained forest monitors investigated locations where deforestation activity had been detected, either physically or with drones, and were remunerated for this work on a monthly basis (Slough et al., 2021). In terms of timescale, Bewick suggested that the turnaround time on getting data to communities ranged from two weeks to a month. A deforestation 'event', by contrast, might occur over a few days. Where monitors encountered deforestation activity, they could intervene directly or take what they had found to a community assembly to make decisions on further action (step 3). Such action might include asserting collective ownership rights (for example, by showing maps of their land to encroaching loggers and farmers), direct confrontation and removal, or documenting deforestation with georeferenced images and measurements to present as part of a *denuncia* [complaint] to state environmental agencies who could support with law enforcement (step 4).

Peru's environmental agencies Organismo de Evaluación y Fiscalización Ambiental (Environmental Evaluation and Enforcement Agency/OEFA) and Fiscalías Especializadas en Materia Ambiental (Specialised Prosecutors in Environmental Matters/FEMA) are under-resourced and exist in a political context where neoliberal values and private interests continue to guide institutional practices despite shifting political pressures both inside and outside of government (Gonzalez, 2019; Orihuela et al., 2021; Paredes and Figueroa, 2021; Vergara and Encinas, 2016). For Indigenous and forest-dwelling peoples, this can lead to inequalities of access to support, reliance on NGOs (Gonzalez, 2019), and delayed and inconsistent responses from national agencies (Orihuela et al., 2021). As Steffen Dalsgaard (2013) argues, the state is not only reproduced spatially, materially, and institutionally *over time*; it is also constituted by the *temporal practices* of state agents and authorities, and the conditions and durations of their attention and responses. Further, state environmental enforcement is restricted to addressing environmental concerns in the terms of land ownership and rights set out in step 1, rather than responding to Indigenous self-determination and other possible forest trajectories.

Bewick (2023) noted that most deforestation cases were dealt with by communities themselves, especially if the people involved were known to or facilitated by members of the community. Tara Slough et al.'s (2021) randomised control trial study of Rainforest Alert's impacts in Loreto in the Peruvian Amazon found that, over the first two years of the programme, there was an overall decrease in tree cover loss during a period of more efficient and 'timely' detection of deforestation activity by communities. Part of this increased efficiency, the study found, emerged from appointing designated forest monitors to carry out patrols, leading to decreased overall community participation and collective action around forest monitoring.

Other public portrayals of Rainforest Alert, however, highlight the temporal tensions in the process. In one example documented on the Global Forest Watch blog (Bewick and Ruiz, 2019) and in a VICE News video (VICE News, 2019), Ticuna forest monitors from Buen Jardín del Callarú in Loreto filed a *denuncia* after they found an area of forest burned and planted with coca. It took several months after filing the complaint for FEMA prosecutors and police to join community monitors to try to confront the people responsible. After a 'slow' two-hour hike to the site (VICE News, 2019), FEMA could not intervene directly because they did not catch the planters in the act. The official investigation that followed, the film emphasises, could take 'eight months or more to complete' (Bewick and Ruiz, 2019; VICE News, 2019).

Where is the real-time in the meantime? When represented for the primarily Anglophone, non-Indigenous audiences of platforms such as the GFW blog and VICE News, this real-time forest is revealed to be a site of contradictions. On the one hand, the video shows the Ticuna monitors and the team from Rainforest Foundation US collaboratively co-producing technologies and ways of being in the forest that make it senseable and (to some extent) defendable from encroachment. However, the Ticuna are presented simultaneously as active agents in forest monitoring, and as victims of local, national, and global systems of forest destruction. This real-time forest is beset by embedded 'slownesses', from the delays and deferrals experienced by Indigenous and rural populations when navigating bureaucratic systems and institutions not built by or for them, to movements of people and data across land not organised by spacetime-compressing infrastructures such as major roads and high-speed internet. The temporal orientations of networked, fossil-fuelled modernity that valorise speed, immediacy and progress come together with realtimeness as the 'shared present' (Rifkin, 2017) that Indigenous peoples must at once participate in

but remain separate from to fit within colonial and state techno-temporal imaginaries of living with the forest.

Timescales of relation

Real-time forests play out across multiple spatio-temporal scales in the context of global environmental crisis. Arguments for near real-time forest monitoring technologies toggle between 'immediately impacted populations' responding in the here-and-now (Slough et al., 2021) and a global environmental citizenry whose futures are bound up with forests, including the Amazon. These temporalities are entangled through digitally mediated understandings of the forest as continually at risk. In this context, Indigenous peoples are often presented as planetary environmental stewards (Merino and Gustafsson, 2021), defending forest environments from the risks of deforestation for a planetary community. During our interview, the Bewick noted that evidence shows that Indigenous peoples are the best protectors of environments (Bewick, 2023; Brondizio and Le Tourneau, 2016; FAO and FILAC, 2021). Indigenous and forest-dwelling peoples are mobilising real-time technologies such as Rainforest Alert for forest protection and governance. Yet these technologies can also operate to keep forest-dwelling communities in a position of perpetual response to others' spatio-temporal advancements in situations of violence and dispossession that are often dangerous, protracted, or uncertain (Global Witness, 2021). In glossing over how longer histories and patterns of dispossession, land commodification, resource extraction, and neoliberal economic and environmental policies together contribute to the fragmentation of forest spaces, the real-time forest risks making the real-time (with its temporal inequalities) the only time that matters, overwriting other temporalities and techno-ontologies of forest relation.

However, Indigenous cosmologies, more-than-human forest relations, and data practices can be mobilised to reshape and ontologically disrupt forest monitoring technologies towards forms of Indigenous self-determination (Westerlaken et al., 2023; Young, 2021). Through the Rainforest Alert programme, ORPIO and other AIDESEP regional organisations have developed data hubs such as the Center for Information and Territorial Planning, allowing for Indigenous-led data management and analysis. Such data infrastructures emerge from calls for Indigenous data sovereignty (Carroll et al., 2020; Kukutai and Taylor, 2016) as the rights of Indigenous peoples to define data relating to their territories and knowledges and to determine how to share, protect, and interpret them. In the context of real-time forests, an important element of Indigenous data sovereignty might be 'temporal sovereignty' (Rifkin, 2017), especially as settler institutions producing or acting on data to govern environments tend to use 'a relatively foreshortened timescale in decision-making, not invoking decades or centuries prior as a basis for action' (Awâsis, 2020: 843). Indigenous data infrastructures built around protocols of data and temporal sovereignty – for example, the Native Land Information System (Native Lands Advocacy Project, 2023), which offers data visualisations to support Indigenous environmental governance and food sovereignty in Turtle Island/North America, among others – open up different timescales for attending to patterns and drivers of extraction, environmental degradation and violence, and to Indigenous frameworks of nonhuman relation across time. In the next section, we turn to artistic and socio-political practices and digital platforms that complicate the real-time epistemologically and politically in generating multi-temporal and anti-colonial praxes of forest relation.

Forest futurisms

Indigenous futurisms offer ways to attend to the durational and non-linear impacts of colonialism and capitalism on environmental temporalities while also attuning to different temporal possibilities. Anishinaabe scholar Grace L. Dillon (2012: 7) describes Indigenous futurisms as diverse techniques of imagining, analysing, and realising Indigenous knowledges and scientific literacies:

> In contrast to the accelerating effect of techno-driven western scientific method, Indigenous scientific literacies represent practices used by Indigenous peoples over thousands of years to reenergize the natural environment while improving the interconnected relationships among all persons (animal, human, spirit, and even machine).

These scientific literacies, Dillon writes, are practised through multiple methods, including technosciences, storytelling, art, and literature. This thinking also complicates what counts as technology, addressing the ways that technology and temporality have been operationalised together in the attempted colonial domination of people and environments. As Diné writer Lou Cornum (2015) notes, conceptions of 'advanced technology' – often involving resource-intensive processes and institutionalised scientific expertise – have been connected to 'advanced civilizations' through notions of linear temporal progress. These same discourses have been developed as tools of colonialism to position Indigenous people and places as anachronistic, 'consigned to the past' (Rifkin, 2017: vii). In this linear narrative, Indigenous knowledge practices are presented as non-technological. As Cheyenne social demographer Desi Rodriguez-Lonebear (2016: 254) writes, '[d]espite centuries of indigenous knowledge production steeped in histories of data collection and analysis [. . .] progress is defined largely in Western terms and measured by Western-identified and controlled indices.'

Potawatomi thinker Kyle Powys Whyte (2018) uses the term 'Indigenous science (fiction)' to describe interconnected environmental and artistic practices that reckon with the durational and recurrent role of colonialism in environmental crisis, from the severing of relations to place and nonhuman relatives through genocide and dispossession, to ongoing extractive regimes contributing to climate change. Indigenous science (fictions) engage 'spiraling time' – a concept Whyte offers in dialogue with Sherry Copenace and Dylan Miner and the Anishinaabe expression *aanikoobijigan* (*yankobjegen*), meaning ancestor and descendant at the same time – to attune to other possible environmental trajectories grounded in Indigenous conceptions of time, intergenerational relation and responsibility. Whyte (2018: 219) writes that spiralling time:

> may be lived through narratives of cyclicality, reversal, dream-like scenarios, simultaneity, counter-factuality, irregular rhythms, ironic un-cyclicality, slipstream, parodies of linear pragmatism, eternality, among many others. The spiraling narratives unfold through our interacting with, responding to and reflecting on the actual or potential actions and viewpoints of our ancestors and descendants. They unfold as continuous dialogues.

Spiralling temporalities complicate the linear accumulations and orientations towards newness and presentness that structure the real-time. What would spiralling time make possible in understandings of and responses to deforestation? What would forest technologies and data platforms made with spiralling time in mind look like, feel like, sound like?

In this half of the article, we turn to artistic, poetic, and socio-political practices that offer ways to think through this question, thereby complicating realtimeness as a techno-temporality of forest knowledges and protection. Importantly, Dillon's discussion of Indigenous futurisms and Whyte's discussion of spiralling time are specifically situated amongst Anishinaabe epistemologies and place-based relations, although both emphasise connections with other Indigenous temporal thinking. Beyond Turtle Island/North America, including in places where political articulations of Indigeneity are complex or contested, others attend to the potential of artistic practices to open up decolonial temporalities and technologies of understanding and relating to environments. For example, Macarena Gómez-Barris (2017: 69) considers how creative practices such as the films of Mapuche filmmaker Francisco Huichaqueo engage non-linear temporalities to re-perceive land that has undergone colonial and capitalist extraction in Latin America as a 'multidimensional space' and 'an archive for the future'. Meanwhile, Yakthung artist Subash Thebe Limbu (2020) articulates Adivasi futurism as a space where Adivasis imagine and produce futures 'where they have agency, technology, sovereignty and also their indigenous knowledge, culture, ethics and storytelling still intact, of course with upgraded codes.'. In the following sections, we consider relationships between intergenerational, more-than-human temporalities and 'upgraded codes' in Indigenous and anti-colonial forest futurisms.

Living configurations

Joana Cabral de Oliveira's (2020: 5) ethnographic work on the 'vegetable temporalities' of the Wajãpi people in the Brazilian Amazon highlights the ways that Amerindian storied interactions between humans and plants interleave mythic, historical, and everyday time:

> [T]he forest is full of markings that make past events more than memorable. Temporality is thus spatialised, providing access to an inescapable past that is inscribed in the trees and many other beings, a past that is activated in the present to make the world's current configuration intelligible.

de Oliveira's description of a continually configured intelligibility materialised through forest spacetime suggests a different real-time modality, a real-time constellated through intergenerational histories of multiple more-than-human rhythms. Beyond the specific context of Wajãpi territory and knowledges that de Oliveira discusses, Amerindian and allied digital practices configure resonantly complex forest temporalities and intelligibilities through multiple media, from online poetry to artistic platforms.

For instance, Wampis/Awajún poet Dina Ananco's poem 'Awan/La caoba/Mahogany' suggests a continually configured 'past that is activated in the present' through a mahogany tree and its relations (Ananco and Yoza, 2022). The poem, from Ananco's collection *Sanchiu*, is published on *Siwar Mayu*, an open access 'multilingual digital collaborative anthology platform' that features poetry by Indigenous writers in native languages, along with translations, with the aim of using the internet as a medium to facilitate trans-Indigenous and wider conversations (Siwar Mayu, n.d). Over the course of Ananco's poem, the mahogany tree grows and transforms through intricate relations with wind and bees, while its relationship with humans becomes increasingly tense, fearing '[t]he man's casual hit with a chainsaw'. Mahogany is a protected species in Wampis territory, which the Wampis Nation declared as under autonomous governance in 2015 (Merino, 2021). However, mahogany remains subject to high levels of illegal logging (Vera, 2022).

Ananco's poem suggests the mutually reinforcing devastations of ecocide and epistemicide where forest relations are living sites and assemblages of knowledge-making across complex temporalities and repeated, everyday violences: '[e]ach wound is renewed at dawn'. In the final lines, the poem considers the implications of these violences for forest futures. (Quoted below are the lines in Wampis, then in Spanish translated by Ananco, then in English translated by Katia Yoza.)

> Arumai pujuti urukuk atiñait nunaka chikichkiksha nekareatsui.
> Numi kanawerkau tura nukerkau aiñasha
> pujutan yawettrau ain
> yaunchukian tura arumaiya nunasha.
>
> Nadie conoce su futuro.
> Tampoco los árboles frondosos
> pese a su experiencia
> del ayer y de sus años venideros.
>
> No one knows his future.
> Neither do the leafy trees
> despite their experience
> of yesterday and their years to come.

In the English translation, 'his future' could refer to the future of the tree, or to the future of the man with the chainsaw. The cutting of the mahogany tree is also the severing of relations and the knowledges they sustain, including the trees' experiential knowledge of 'yesterday and their years to come' through an interconnected past and future held together on the same poetic line.

Other digital practices articulate an interconnected, continually reconfigured 'yesterday' and 'to come' in terms of biocultural duration and resurgence. Devenir Universidad (Becoming University) is a digital 'platform to support the co-creation of a university led by the Inga people' living between the Amazon and the Andes in Colombia (Devenir Universidad, 2023). The university is in the process of formation, as indicated by the verb *devenir*/becoming in the platform's title, and involves Inga and non-Inga researchers, including the Swiss artist Ursula Biemann who was invited into the project and conceptualised the online platform. Crucially, it is grounded in the forest as a 'territorio cognitivo vivo' or 'living cognitive territory', where:

> [T]erritory is person, or better yet, a multitude of persons organized as a socio-ecological kinship. But the territory is not only a person: she is also a meeting point where lifeways cross each other forming a living tapestry or tejido vivo. What is commonly known as the web of life, that is, the relationships between organisms in an ecological community, is not a network of pre-existent points that connect to each other, but a meshwork of interwoven lines in relentless movement and change. For example, meandering rivers, growing plants, human and non-human animals, and even language, are all life forms or trajectories of growth and movement that emerge together and reconfigure the territorial fabric into infinite designs. (Devenir Universidad, 2023)

The university does not prioritise resource-intensive scientific real-time monitoring technologies in its knowledge-making processes. By contrast, its self-description as a collective effort to rebuild Inga knowledge systems and biocultural practices by 'collectively

processing the ever-changing interactions between the different entities involved in meaning and world-making' offers a situated, pluri-epistemic framework for multi-temporal, continuous *relations with* the forest, in and against ongoing presents of dispossession, resource extraction, and epistemic domination. As Devenir Universidad's processes of *becoming* take place not only in Inga territory, but also through a digital platform facilitating interactions with a multiplicity of actors (including those at physical and epistemic distance from the relations and politics of the 'living cognitive territory', such as the authors of this article), we turn to the techno-temporal dimensions of the project *as a platform*. Digital platforms are key sites through which real-time forests are made senseable, and in the next, final section of the article, we consider Devenir Universidad together with another artistic and political platform, the Forest Curriculum, as interventions in the platforming of forest time.

Platforming forest time

A platform is 'the ground, foundation, or basis of an action, event, calculation, condition, etc.' (*OED*), but the term increasingly refers to digital media interfaces and infrastructures. A growing number of digital platforms record, process, and visualise data about forest environments (Gabrys, 2020; Urzedo et al., 2022). Often data-driven, such platforms require large data infrastructures and are therefore mostly designed by and for state or private corporate actors, while also facilitating participation from 'stakeholders' (ranging from scientists to local government workers to investors to community members). In their survey of digital technologies used for urban forest management, Sophie Nitoslawski et al. (2021) identify platforms as a key way through which publics (positioned as 'citizens' or 'stakeholders') are invited to participate in management processes through public consultations or interactive maps that enable residents to share information about their local environment. Digital platforms can act as 'participatory ecosystems' (Barns, 2019) that shape and regulate the forms that participation can take, 'ecosystems' that are not merely metaphorical but made up of specific material assemblages and infrastructures (Plantin and Punathambekar, 2019). They are paradoxical structures: at once distributed and centralised, transparent and opaque, top-down and bottom-up (Van Dijck et al., 2018). Temporally, platforms often produce and valorise realtimeness as a quality of interactions with accumulating or newly available data (Lupinacci, 2022; Weltevrede et al., 2014). Such data practices record but can also influence the pacing of nonhuman rhythms, forest labour and living (Prebble et al., 2021).

As a platform, Devenir Universidad facilitates slower engagements than other recent forest data platforms. The project description at the top of the homepage includes hyperlinks to key concepts that are also summarised lower down the page, creating a multi-scalar, interwoven site navigation. When scrolling, graphic symbols of Inga women's chumbe (woven belt) designs appear. As Inga scholar Benjamin Jacanamijoy Tisoy (Devenir Universidad, 2023) notes, chumbe are woven to tell personal and community histories. Clicking between pages produces a loading message: 'Espere un momento por favor . . ./ Wait a moment please. . .' (Devenir Universidad, 2023). Instead of quantitative data on forest processes, the platform foregrounds audiovisual media, including interviews with Inga knowledge-holders and educators, and video archives of 'minga de pensamiento' or collective thinking between collaborators. As Waira Nina Jacanamijoy notes in one interview, the elders went around their 'gran territorio, siempre lo andaron. Frecuentemente' [great territory, they always walked it. Frequently'] (Jacanamijoy, 2021). Walking and the expanded temporalities of the yagé medicinal plant pace Inga forest worlds, forms of governance, knowledge-making, and futurisms. If, as leader Hernando Chindoy Chindoy (2021)

suggests, one of the main aims of the university is to stay 'close to our territory' and to guard it against resource extraction companies and 'their conceptions of life', then perhaps the project could be compared to the community patrols of Rainforest Alert. However, crucially, Devenir Universidad emphasises the integration of epistemological, spiritual, and political elements that allow for reframing techno-temporalities of crisis.

Realtimeness, we suggest, is concerned with availability as well as speed of access in uneven and often extractive knowledge and data economies. The Inga complicate knowledge production by building interconnected territorial and epistemic sovereignty as part of a pluriversal politics. As non-Indigenous scholars writing in relation to these pluriversal practices, it seems important to consider what is *not* made available on platforms such as Devenir Universidad, and what anti-colonial, anti-extractive, and Indigenous platforms could potentiate and perform in terms of slowing down, rerouting, and transforming the accumulative and instantaneous temporal logics and desires structuring forest data platforms.

In a resonant way, the Forest Curriculum (2023) describes itself as 'a collectively run itinerant anarchist platform for artistic, curatorial and political research and organisation'. A shifting collective co-founded by curators Pujita Guha and Abhijan Toto, the Forest Curriculum is multi-located, but situates itself in the histories, knowledges, and relations in 'the forested belt running from the northeast of India, through the Chittagong Hill Tracts of Bangladesh, the Shan state, the Isan heartland in Thailand, the tropical forests of the Malay Peninsula and into the Cordilleras of the Philippines' (Guha and Toto, 2021b: 103). In these geographies, land has often been contested and political articulations of identity and Indigeneity are shifting and complex (Baird, 2016; Bose et al., 2012; Ironside, 2022; Scott, 2009; Shah, 2007). Guha and Toto (2021b: 109) write that, in these forested places, 'there is no post-colonial but rather entangled histories of imperialism, that occur not as geological layers, but rather co-temporaneously, and all at once.' Through artistic, curatorial, and activist practices, the Forest Curriculum mobilises located, multiple, and colliding forest spacetimes as ways to approach contemporary knowledge production, land struggles, and their entanglement with urban and digital life.

However, the Forest Curriculum's self-description as a platform (and specifically a 'collectively run itinerant anarchist platform') seems to slow down the intertwined temporal and data logics of platforms. In an interview, Pujita Guha, co-founder and former contributor to the Forest Curriculum, noted that while the project necessarily uses existing web and social media platforms (including Facebook, Instagram, and Zoom) to communicate across multiple time zones and to share and archive activities, these digital spaces do not constitute the dominant meaning of 'platform' in the Forest Curriculum's practice (Guha, 2022; see also a podcast version of this interview in Guha et al., 2023). Some activities align with established institutional models of artistic research and uses of platforms. For example, the workshop series 'The Forest is in the City is in the Forest' brought together artists and activists through existing digital participatory platforms to share thinking on topics of forest militarisation, Indigeneity, land sovereignty, and food security, de/anti-colonial approaches to nonhuman agency, and infrastructure and logistics (Forest Curriculum, 2020–2021). However, in questioning and reconstituting platform logics, the Forest Curriculum also dedicates time and space to ways of working that are deliberately or formally less legible to digital audiences (Guha, 2022).

Complicating the use of digital platforms as sites of participation, connection, and knowledge-sharing, the Forest Curriculum's (multi)situated work highlights inequalities, risks, and forms of extraction embedded in digital technologies. As Guha noted in our interview, in some locations state surveillance shapes digital platform use, especially for anti-colonial, Indigenous, and counter-hegemonic projects and organisations. In other

places, unequal distributions of technology mean that project funds could be used up on devices such as laptops and phones, curtailing other community- and knowledge-building possibilities. At stake here are not only questions of permission, economic, and technological capacity, but also epistemology, politics, and temporality. In seeking to 'creat[e] situations of mutual stakeholding of knowledge', the Forest Curriculum suggests a need to 'imagine what forms of politics and pedagogies must be invented to think alongside, and become intimate with the many beings of the many worlds we inhabit' (Guha and Toto, 2021b: 111). In this futural, durational practice, simultaneous co-presence in a shared physical space may be neither possible nor, perhaps, desirable across different histories of relation to land, and multiple temporal and spatial knowledges. The Forest Curriculum asks how environmental knowledges can be made that are 'not entirely tethered to data via digital networks and digital infrastructures' (Guha, 2022), and how these knowledges can unfold temporally. This work contends with the uneven infrastructures, material and conceptual labours of co-assembling and sustaining socio-ecological communities beyond (plat)forms that reinscribe patterns of dispossession and extraction as their unspoken conditions of possibility.

While 'everybody has some impetus in calculation' (Guha, 2022) – including strategic engagements with data and the timing of political, social, and environmental interventions – the Forest Curriculum also articulates value in remembering and collectively co-inventing 'forms of sensory experiences that are not entirely governed or made to calculate or [be] calculable in some way.' This perspective troubles the primacy of real-time forests as trackable, quantifiable spaces oriented around a singular (colonial) present. Instead, the Forest Curriculum suggests the potential of incalculability as a political heuristic that necessarily fails to account (in linear or quantitative terms) for the material, epistemic, and temporal violences enacted by colonial and capitalist technologies, and instead 'flourishes on the glitch or the error which refuses to settle' (Guha and Toto, 2021a). In doing so, their practice attempts to 'produce openings by which time-beings might find ways to endure' (Barad, 2017: 63) that are perhaps opaque or uncapturable in the terms of the real-time.

For the Forest Curriculum, neither ancestry nor technological development are linear or confined to the human, but rather take place through contingent relations with remembered and potential forests, more-than-human kin, socio-political movements, glitches and ghosts. Longstanding attention to and struggle in and for the forest have produced technologies that have been honed, cultivated, and shared. At the same time, the Forest Curriculum articulates multiple refusals: refusal of techno-capitalism as the basis for understanding, pacing, and governing forest technologies; refusal of colonial conceptions of forest spaces that erase Indigenous lifeways, nonhuman relations, and queer temporal possibilities; and refusal of technological instruments oriented around capturing Indigenous and embodied knowledges as accumulable data. Listening to these articulations, we do not propose an abandonment of real-time technologies that offer ways of understanding and documenting patterns of environmental change and violence. Rather, nurturing the multi-temporal and the pluralistically durational aspects of forest technologies opens ways to build socio-ecological knowledges beyond extractive systems, with attention to reparative and redistributive movements and data justice.

Conclusion: pluralising forest futurisms

Forests are zones of multiple temporalities. They keep time and they are constituted through time-keeping practices. Technologies and temporalities of pacing, measuring, sensing, and responding to forests are not only co-constitutive but also consequential. As this article has explored, real-time forests materialise through multiple scales of technoscientific and

political agency, from large-scale remote sensing networks and data infrastructures to interpersonal interactions and contested governance structures concerning territory, environment, and data. In accumulating data while continually reasserting the present (a technologically calibrated present in the linear, progressive timelines instituted by colonial epistemologies), real-time forests generate important forms of accounting and accountability that simultaneously risk overwriting the structural conditions and multiple temporalities constituting forest lifeways amongst intensifying climate crisis and renewed and emerging forces of dispossession and extraction.

Practices of sensing and responding to these multiple temporalities require not just different technologies but also pluralistic engagements for inhabiting, transforming, and honouring forest spacetimes. Our attention to interconnected artistic and socio-political practices that propose and provide other temporal orientations attempts to generate critical vocabularies of sensing the histories, hauntings, and more-than-human frequencies of forests as shifting relational environments. These temporal considerations are more than a matter of multiplying modes of experience; they indicate ways of acknowledging forests as ongoing spacetime compositions, where colonial histories, dispossession, and deforestation collide with neocolonial forest conservation practices and technologies. Ongoing efforts to build knowledges and practices that contest and reimagine climate colonialism and neo-extractivism might also involve forms of waiting, inheriting, relationship-building, pluralistic timing, and *not* knowing in attuning to socio-ecological temporalities across uneven terrains. Rather than foreground one mode of keeping time with forest technologies, such engagements would require expanding temporalities toward more equitable forest pasts, presents, and futures.

Acknowledgements

Thanks are due to Tom Bewick and Pujita Guha for their informative and generous interviews that contributed to this research and writing. Dina Ananco and Katia Yoza kindly granted permission to reproduce an excerpt from Ananco's poetry. We are also grateful to the anonymous reviewers and EPD editorial member Andrew Curley for their insightful and constructive suggestions.

Declaration of conflicting interests

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

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (Grant agreement no. 866006).

ORCID iDs

Kate Lewis Hood https://orcid.org/0000-0001-6473-7608
Jennifer Gabrys https://orcid.org/0000-0001-5545-2459

Notes

1. This changed under Forest and Wildlife Law 2011 (Ley Forestal y de Fauna Silvestre, no. 29763, 2011), which defined six new units of forest management: 'Forests of Permanent Production', (*Bosques de producción permanente*), 'Local Forests' (*Bosques locales*), 'Forests in Reserve'

(*Bosques en reserva*), 'Protected Forests' (*Bosques protectores*), 'Forests on peasant and native land' (*Bosques en tierras de comunidades campesinas y nativas*), and 'Forests on private landholdings' (*Bosques en predios privados*) (Sax, 2020).

2. Indigenous communities have resisted these policies. Most notably, in 2009, Indigenous people and organisations, including AIDESEP, resisted resource extraction in the Peruvian Amazon following a free trade agreement between Peru (under President Alan García's leadership) and the United States. In June 2009, President García sent in the military, and the violence that followed (sometimes referred to as the Bagua massacre) resulted in the deaths of 10 Indigenous people, injuries to 150 more, and the deaths of 23 police officers.

References

Ananco D and Yoza K (2022) Sanchiu. *Siwar Mayu*. Available at: https://siwarmayu.com/sanchiu-dina-ananco/ (accessed 5 July 2023).

Asiyanbi AP, Ogar E and Akintoye OA (2019) Complexities and surprises in local resistance to neoliberal conservation: Multiple environmentalities, technologies of the self and the poststructural geography of local engagement with REDD+. *Political Geography* 69: 128–138.

Awâsis S (2020) 'Anishinaabe time': Temporalities and impact assessment in pipeline reviews. *Journal of Political Ecology* 27(1): 830–852.

Baird I (2016) Indigeneity in Asia: An emerging but contested concept. *Asian Ethnicity* 17(4): 501–505.

Bakker K and Ritts M (2018) Smart Earth: A meta-review and implications for environmental governance. *Global Environmental Change* 52: 201–211.

Barad K (2017) Troubling time/s and ecologies of nothingness: Re-turning, re-membering, and facing the incalculable. *New Formations* 92: 56–86.

Barns S (2019) Negotiating the platform pivot: From participatory digital ecosystems to infrastructures of everyday life. *Geography Compass* 13: e12464.

Barton GA (2002) *Empire Forestry and the Origins of Environmentalism*. Cambridge: Cambridge University Press.

Bewick T (2023) Interviewed by K Lewis Hood and J Gabrys. 6 February, online.

Bewick T, Lewis Hood K and Gabrys J (2024) Rainforest Alert: Indigenous monitoring in the Peruvian Amazon. Smart Forests Atlas. Available at: https://atlas.smartforests.net/en/radio/rainforest-alert (accessed 31 January 2024).

Bewick T and Ruiz S (2019) Smartphones and satellite imagery: Bringing environmental enforcement to the Peruvian Amazon. Global Forest Watch. Available at: https://www.globalforestwatch.org/blog/people/smartphones-and-satellite-imagery-bringing-environmental-enforcement-to-the-peruvian-amazon/ (accessed 8 March 2023).

Bose P, Arts B and Van Dijk H (2012) 'Forest governmentality': A genealogy of subject-making of forest-dependent 'scheduled tribes' in India. *Land Use Policy* 29(3): 664–673. https://doi.org/10.1016/j.landusepol.2011.11.002.

Brondizio ES and Le Tourneau FM (2016) Environmental governance for all. *Science (New York, N.Y.)* 352: 1272–1273.

Campbell JL, Rustad LE, Bailey SW, et al. (2021) Watershed studies at the Hubbard Brook Experimental Forest: Building on a long legacy of research with new approaches and sources of data. *Hydrological Processes* 35(1): e14016.

Carroll SR, Garba I, Figueroa-Rodríguez OL, et al. (2020) The CARE Principles for Indigenous data governance. *Data Science Journal* 19(1): 43.

Carroll SR, Herczog E, Hudson M, et al. (2021) Operationalizing the CARE and FAIR Principles for Indigenous data futures. *Scientific Data* 8: 108.

Chindoy H (2021), Interview with Hernando Chindoy, leader of the Inga community in South Colombia answers three questions regarding the planned Indigenous University in their territory. Devenir Universidad. https://deveniruniversidad.org/en/art-and-audiovisual-media/video-collection/ (accessed 24 January 2024).

Cornum L (2015) The space NDN's star map. *The New Inquiry*, 26 January. Available at: https://thenewinquiry.com/the-space-ndns-star-map/ (accessed 5 July 2023).

Curley A and Smith S (2023) The cene scene: Who gets to theorize global time and how do we center Indigenous and black futurities? *Environment and Planning E: Nature and Space* :1–34. Online first. https://doi.org/10.1177/25148486231173865.
Dalsgaard S (2013) The time of the state and the temporality of the *Gavman* in Manus Province, Papua New Guinea. *Social Analysis* 57(1): 34–49.
Dávalos LM, Sanchez KM and Armenteras D (2016) Deforestation and coca cultivation rooted in twentieth-century development projects. *BioScience* 66(11): 974–982.
de la Cadena M (2010) Indigenous cosmopolitics in the Andes: Conceptual reflections beyond 'politics'. *Cultural Anthropology* 25(2): 334–370.
De Leeuw S and Hunt S (2018) Unsettling decolonizing geographies. *Geography Compass* 12(7): 1–14. https://doi.org/10.1111/gec3.12376.
de Oliveira JC (2020) Vegetable temporalities: Life cycles, maturation and death in an Amerindian ethnography. *Vibrant* 17(4): 1–18. https://doi.org/10.1590/1809-43412020v17a359.
Devenir Universidad, Indigenous Inga people of Colombia, Biemann U (2023) Devenir Universidad. Available at: https://deveniruniversidad.org/en/home/ (accessed 15 December 2023).
Devine JA and Baca JA (2020) The political forest in the era of green neoliberalism. *Antipode* 52: 911–927.
Dillon GL (ed.) (2012) *Walking the Clouds: An Anthology of Indigenous Science Fiction*. Tucson: University of Arizona Press.
FAO and FILAC (2021) Forest Governance by Indigenous and Tribal Peoples: An Opportunity for Climate Action in Latin America and the Caribbean. Santiago. Available at: https://doi.org/10.4060/cb2953en (accessed 15 December 2023).
FAO and UNEP (2020) The state of the World's Forests 2020. Forests, biodiversity and people. Rome. Available at: https://doi.org/10.4060/ca8642en (accessed 15 December 2023).
Finer M, Novoa S, Weisse MJ, et al. (2018) Combating deforestation: From satellite to intervention. *Science* 360(6395): 1303–1305.
Forest Curriculum (2020–2021) The Forest Curriculum. Facebook. Available at: www.facebook.com/forestcurriculum/ (accessed 13 July 2023).
Forest Curriculum (2023) @theforestcurriculum. Instagram. Available at: www.instagram.com/theforestcurriculum/ (accessed 5 July 2023).
Futuros Indígenas (2021) Manifiesto. Available at: https://futurosindigenas.org/manifiesto/ (accessed 5 July 2023).
Gabrys J (2016) Program Earth: Environmental Sensing Technology and the Making of a Computational Planet. Minneapolis: University of Minnesota Press.
Gabrys J (2019) *How to Do Things with Sensors*. Minneapolis: University of Minnesota Press.
Gabrys J (2020) Smart forests and data practices: From the Internet of Trees to planetary governance. *Big Data & Society* 7(1): 1–10. https://doi.org/10.1177/2053951720904871.
Gabrys J (2022) The forest that walks: Digital fieldwork and distributions of site. *Qualitative Inquiry* 28(2): 228–235.
Gabrys J, Westerlaken M, Urzedo D, et al. (2022) Reworking the political in digital forests: The cosmopolitics of socio-technical worlds. *Progress in Environmental Geography* 1(1–4): 58–83.
Global Forest Watch (2023) About. Available at: www.globalforestwatch.org/about/ (accessed 5 July 2023).
Global Witness (2021) Last line of defence. Available at: www.globalwitness.org/en/campaigns/environmental-activists/last-line-defence/ (accessed 5 July 2023).
Gómez-Barris M (2017) *The Extractive Zone: Social Ecologies and Decolonial Perspectives*. Durham: Duke University Press.
Gonzalez A (2019) Making "a racket" but does anybody care? A study of environmental justice access and recognition through the political ecology of voice. *Geoforum* 102: 142–156.
Guha P (2022) Interviewed by K Lewis Hood and J Gabrys. 13 December, online.
Guha P and Toto A (2021a) Coding a forest. *Esperanto* 2: 38.
Guha P and Toto A (2021b) To speak to the forest. *Antennae* 2: 102–113.

Guha P, Lewis Hood K and Gabrys J (2023) Pujita Guha for the Forest Curriculum: Building knowledges beyond data. Smart Forests Atlas. Available at: https://atlas.smartforests.net/en/radio/pujita-guha (accessed 25 January 2024).

Ironside J (2022) Localizing global concepts: An exploration of Indigeneity in Cambodia. *Critical Asian Studies* 54(3): 374–397.

Jacanamijoy WA (2021) Interview with Waira Nina Jacanamijoy of the Indigenous Inga of Colombia in Caquetá on their territorial history in Putumayo and Caquetá. Devenir Universidad. Available at: https://deveniruniversidad.org/en/art-and-audiovisual-media/video-collection/ (accessed 15 December 2023).

Jamilla S (n.d) Lessons learned from evaluating an open data platform: The impact assessment of global forest watch. Merl Center. Available at: https://merlcenter.org/caseStudies/the-impact-assessment-of-global-forest-watch/ (accessed 8 March 2023).

Kamphof I (2013) Linking animal and human places: The potential of webcams for species companionship. *Animal Studies Journal* 2(1): 82–102.

Kukutai T and Taylor J (2016) (eds) *Indigenous Data Sovereignty: Toward an Agenda*. Canberra: Australian National University Press.

Limbu ST (2020) Adivasi futurism. Available at: https://subashthebe.com/wp-content/uploads/2020/08/Adivasi-Futurism-subash-thebe-limbu.pdf (accessed 5 July 2023).

Loseto LL, Breton-Honeyman K, Etiendem DN, et al. (2020) Indigenous participation in peer review publications and the editorial process: Reflections from a workshop. *Arctic Science* 6(3): 35–2360.

Lupinacci L (2022) Phenomenal algorhythms: The sensorial orchestration of 'real-time' in the social media manifold. *New Media & Society*: 1–21. Epub ahead of print, 24 July. https://doi.org/10.1177/14614448221109952.

Merino R (2021) Buen vivir and the making of Indigenous territories in the Peruvian Amazon. *Latin American Perspectives* 48(3): 136–151.

Merino R and Chinchay A (2022) Between the environment and the economy: Foreign investments, global conservation, and Indigenous nations in the Amazon. *Globalizations* 19(6): 887–896.

Merino R and Gustafsson MT (2021) Localizing the indigenous environmental steward norm: The making of conservation and territorial rights in Peru. *Environmental Science & Policy* 124: 627–634.

Miller J and Nay E (2022) Ontological upgrade: Indigenous futures and radical transformation. *SPOOL* 9(2): 1–12.

Moffette F, Alix-Garcia J, Shea K, et al. (2021) The impact of near-real-time deforestation alerts across the tropics. *Nature Climate Change* 11: 172–178.

Monterroso I, Cronkleton P, Pinedo D, et al. (2017) *Reclaiming Collective Rights: Land and Forest Tenure Reforms in Peru (1960–2016)*. *Working Paper 224*. Bogor: CIFOR.

Musinsky J, Tabor K, Cano CA, et al. (2018) Conservation impacts of a near real-time forest monitoring and alert system for the tropics. *Remote Sensing in Ecology and Conservation* 4(3): 189–196.

Native Lands Advocacy Project (2023) Native land information system. Available at: https://nativeland.info (accessed 16 December 2023).

Nitoslawski SA, Wong-Stevens K, Steenberg JWN, et al. (2021) The digital forest: Mapping a decade of knowledge on technological applications for forest ecosystems. *Earth's Future* 9: e2021EF002123.

Orihuela JC, Cavero CP and Contreras C (2021) Extractivism of the poor: Natural resource commodification and its discontents. *The Extractive Industries and Society* 9: 100986.

Paneque-Gálvez J, Vargas-Ramírez N, Napoletano BM, et al. (2017) Grassroots innovation using drones for indigenous mapping and monitoring. *Land* 6(4): 86.

Paredes M and Figueroa L (2021) New institutions, old practices: The weakening of new environmental control institutions in Peru. In: Damonte G and Schorr B (eds) *Andean States and the Resource Curse: Institutional Change in Extractive Economies*. London: Routledge, pp. 198–217.

Peluso NL and Vandergeest P (2001) Genealogies of the political forest and customary rights in Indonesia, Malaysia, and Thailand. *The Journal of Asian Studies* 60(3): 761–812.

Peluso NL and Vandergeest P (2011) Political ecologies of war and forests: Counterinsurgencies and the making of national natures. Annals of the Association of American Geographers 101(3): 587–608. 10.1080/00045608.2011.560064.

Peluso NL and Vandergeest P (2020) Writing political forests. *Antipode* 52: 1083–1103.
Plantin JC and Punathambekar A (2019) Digital media infrastructures: Pipes, platforms, and politics. *Media, Culture & Society* 41(2): 163–174.
Pokorny B, Robiglio V, Reyes M, et al. (2021) The potential of agroforestry concessions to stabilize Amazonian forest frontiers: A case study on the economic and environmental robustness of informally settled small-scale cocoa farmers in Peru. *Land Use Policy* 102: 105242.
Pratihast AK, DeVries B, Avitabile V, et al. (2016) Design and implementation of an interactive web-based near real-time forest monitoring system. *PLOS One* 11(3): e0150935.
Prebble S, McLean J and Houston D (2021) Smart urban forests: An overview of more-than-human and more-than-real urban forest management in Australian cities. *Digital Geography and Society* 2: 100013.
Radjawali I, Pye O and Flitner M (2017) Recognition through reconnaissance? Using drones for counter-mapping in Indonesia. *The Journal of Peasant Studies* 44(4): 817–833.
Rainforest Connection (2023) Available at: https://rfcx.org (accessed 5 July 2023).
Rainforest Foundation US (2021) Rainforest Alert: Community-based solutions to rainforest destruction now scientifically proven. YouTube, 13 July. www.youtube.com/watch?v=nBqXjE4sywg (accessed 5 July 2023).
Ravikumar A, Sears RR, Cronkleton P, et al. (2017) Is small-scale agriculture really the main driver of deforestation in the Peruvian Amazon? Moving beyond the prevailing narrative. *Conservation Letters* 10: 170–177.
Rifkin M (2017) *Beyond Settler Time: Temporal Sovereignty and Indigenous Self-Determination*. Durham: Duke University Press.
Rodriguez-Lonebear D (2016) Building a data revolution in Indian country. In: Kukutai T and Taylor J (eds) *Indigenous Data Sovereignty: Toward an Agenda*. Canberra: Australian National University Press, pp. 253–72.
Sax S (2020) Invisible territory: Mapping land-use change and power in the Peruvian Amazon. *Journal of Land Use Science* 15(2–3): 290–305.
Scott JC (2009) *The Art of Not Being Governed: An Anarchist History of Upland Southeast Asia*. New Haven: Yale University Press.
Shah A (2007) The dark side of Indigeneity? Indigenous people, rights and development in India. *History Compass* 5(6): 1806–1832.
Shin KG and Ramanathan P (1994) Real-time computing: A new discipline of computer science and engineering. *Proceedings of the IEEE* 82(1): 6–24.
Simpson A (2014) The ruse of consent and the anatomy of 'refusal': Cases from indigenous North America and Australia. *Postcolonial Studies* 20(1): 18–33.
Simpson LB (2017) *As We Have Always Done: Indigenous Freedom through Radical Resistance*. Minneapolis: University of Minnesota Press.
Siwar Mayu (n.d) The project. *Siwar Mayu*. Available at: https://siwarmayu.com/por-que-2/ (accessed 4 January 2024).
Slough T, Kopas J and Urpelainen J (2021) Satellite-based deforestation alerts with training and incentives for patrolling facilitate community monitoring in the Peruvian Amazon. *Proceedings of the National Academy of Sciences* 118(29): e2015171118.
Souza C, Urzedo D, Gabrys J and Westerlaken, M (2023) Carlos Souza: Remote sensing in the Amazon. *Smart Forests Atlas*. Available at: https://atlas.smartforests.net/en/radio/carlos-souza/ (accessed 26 January 2024).
Turnbull J, Searle A, Hartman Davies O, et al. (2023) Digital ecologies: Materialities, encounters, governance. *Progress in Environmental Geography* 2(1–2): 3–32.
Urzedo D, Westerlaken M and Gabrys J (2022) Digitalizing forest landscape restoration: A social and political analysis of emerging technological practices. *Environmental Politics* 32(3): 485–510.
Van Dijck J, Poell T and De Waal M (2018) *The Platform Society*. New York: Oxford University Press.
Vandergeest P and Peluso NL (2006a) Empires of forestry: Professional forestry and state power in Southeast Asia, part 1. *Environment and History* 12(1): 31–64.

Vandergeest P and Peluso NL (2006b) Empires of forestry: Professional forestry and state power in Southeast Asia, part 2. *Environment and History* 12(4): 359–393.
Vera E (2022) Illegal logging and trade in fine wood threaten Wampis communities in the Peruvian Amazon. Trans. Sims S. *Mongabay*, 9 September. Available at: https://news.mongabay.com/2022/09/illegal-logging-and-trade-in-fine-wood-threaten-wampis-communities-in-the-peruvian-amazon/ (accessed 17 March 2023).
Vergara A and Encinas D (2016) Continuity by surprise: Explaining institutional stability in contemporary Peru. *Latin American Research Review* 51(1): 159–180.
VICE News (2019) Indigenous Peruvians are using satellites and drones to fight deforestation. YouTube. Available at: www.youtube.com/watch?v=0s5yhms0vzY& (accessed 8 March 2023).
Wajcman J (2015) *Pressed for Time: The Acceleration of Life in Digital Capitalism*. Chicago: University of Chicago Press.
Watts V (2013) Indigenous place-thought and agency amongst humans and non humans (First Woman and Sky Woman go on a European world tour!.). *Decolonization: Indigeneity, Education & Society* 2(1): 20–34.
Weltevrede E, Helmond A and Gerlitz C (2014) The politics of real-time: A device perspective on social media platforms and search engines. *Theory, Culture & Society* 31(6): 125–150.
Westerlaken M, Gabrys J, Urzedo D, et al. (2023) Unsettling participation by foregrounding more-than-human relations in digital forests. *Environmental Humanities* 15(1): 87–108.
Whyte KP (2017) Our ancestors' dystopia now: Indigenous conservation and the Anthropocene. In: Heise UK, Christen J and Neimann M (eds) *The Routledge Companion to the Environmental Humanities*. Abingdon: Routledge, pp. 206–215.
Whyte KP (2018) Indigenous science (fiction) for the Anthropocene: Ancestral dystopias and fantasies of climate change crises. *Environment and Planning E: Nature and Space* 1(1–2): 224–242.
Williamson B, Provost S and Price C (2023) Operationalising Indigenous data sovereignty in environmental research and governance. *Environment and Planning F* 2(1–2): 281–304.
Young JC (2021) Environmental colonialism, digital indigeneity, and the politicization of resilience. *Environment and Planning E: Nature and Space* 4(2): 230–251.
Zweifel R, Pappas C, Peters RL, et al. (2023) Networking the forest infrastructure towards near real-time monitoring – A white paper. *The Science of the Total Environment* 872: 162167.

Kate Lewis Hood is an ESRC Postdoctoral Fellow in the Department of Geography at Royal Holloway University of London, and a former Research Associate on the Smart Forests project in the Department of Sociology at the University of Cambridge. Kate's research is concerned with how creative practices contribute to spatio-temporal understandings and politics in environments transformed by colonialism, racial capitalism, and ecocide, in dialogue with Black and Indigenous studies, environmental humanities, and geopoetics. Kate's work can be found in *GeoHumanities, Environmental Humanities,* and *Green Letters*.

Jennifer Gabrys is Chair in Media, Culture and Environment in the Department of Sociology at the University of Cambridge. She leads the Planetary Praxis research group and is Principal Investigator on the ERC-funded project, Smart Forests: Transforming Environments into Social-Political Technologies. Her recent publications include *Citizens of Worlds: Open-Air Toolkits for Environmental Struggle* (2022), *How to Do Things with Sensors* (2019), and *Program Earth: Environmental Sensing Technology and the Making of a Computational Planet* (2016). She co-edits the book series, *Planetarities*, published through Goldsmiths Press.