Unsettling Participation by Foregrounding More-than-Human Relations in Digital Forests

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Abstract The question of who participates in making forest environments usually refers to human stakeholders. Yet forests are constituted through the participation of many other entities. At the same time, digital technologies are increasingly used in participatory projects to measure and monitor forest environments globally. However, such participatory initiatives are often limited to human involvement and overlook how more-than-human entities and relations shape digital and forest processes. To disrupt conventional anthropocentric understandings of participation, this text travels through three different processes of "unsettling" to show how more-than-human entities and relations disrupt, rework, and transform digital participation in and with forests. First, forest organisms as bioindicators signal environmental changes and contribute to the formation and operation of digital sensing technologies. Second, speculative blockchain infrastructures and decision-making algorithms raise questions about whether and how forests can own themselves. Third, Amerindian cosmologies redistribute subjectivities to change how digital technologies identify and monitor forests within Indigenous territories. Each of these examples shows how more-than-human participation can rework participatory processes and digital practices in forests. In a time when forests are rapidly disappearing, an unsettled and transformed understanding of participation that involves the world-making practices of more-than-human entities and relations can offer more pluralistic and expansive forest inhabitations and futures.

Keywords participation, more-than-human, smart forests, digital technology, multispecies

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Introduction

Forests across the globe have been sites of collective engagement across humans and more-than-human entities for thousands of years—for example, within Indigenous cultural practices in Great Northern Forests, biodiversity monitoring practices in the Amazon, and cultural burning in Australia.[1] However, industrialized and institutionalized forest practices have become dominant modes of governing and managing forests worldwide. These management practices build on colonial forest governance. They further involve including distinct stakeholders and excluding those who are not authorized to contribute to forest management. Participation in forests, often with digital technologies, has thus become settled as an activity involving specific human stakeholders contributing to decision-making processes. Such established participatory dynamics can both reinforce and challenge environmental privilege and power.

In response to colonial governance and industrialized forest management, community forestry and other participatory initiatives emerged to redistribute decision-making power. Community participation has a long history of conflicts, debates, and negotiations within the context of decentralizing powerful actors in forest access and tenure to legitimize management practices.[2] On a local level, communities have been fighting for environmental self-determination aligned with more inclusive forms of participation in knowledge production and political decision-making. Participatory practices create new negotiation forms that respond to local communities' political, economic, and environmental circumstances. However, even with these initiatives, participation in forests often tends to adhere to Western epistemologies by including humans as the primary—and potentially only—stakeholders in managing forests.

Human participants are often involved with forests through digital forms of participation, which involve collective data gathering, participatory monitoring, or interaction through digital platforms. Given ongoing global environmental challenges, digital technologies have come to play a central role in monitoring and managing forests. Such digitally constituted forests, also referred to as smart forests or digital forests, operate through digital infrastructures that change understandings of forests and generate different practices and ontologies for addressing environmental change.[3] These technologies range from people locally interacting with GPS devices and sensors that log forest conditions and territories to satellite imagery, Lidar systems, and online carbon offsetting platforms. Through measuring and monitoring, these digital technologies forge new environments and relations. In other words, they redistribute attention, create new relations, and propose how participants could interact with these technologies and the

1. Asselin, "Indigenous Forest Knowledge"; Baniwa, *Bem viver e viver bem*; Steffensen, *Fire Country*; Tengö et al., "Connecting Diverse Knowledge Systems."

2. Agrawal, "Participatory Exclusions"; McDermott and Schreckenberg, "Equity in Community Forestry"; Peluso, "Whose Woods Are These?"

3. Gabrys, "Smart Forests and Data Practices."

forests they survey. In this way, the use of digital technologies in participatory processes can reconfigure forest management practices, give rise to new forms of empowerment, and reinforce patterns of privilege and exclusion—for example, by enabling the involvement of certain community members or stakeholders over others.

Many of these contemporary digital forest initiatives, however, reassert an anthropocentric conception of forest environments as spaces to be managed by humans. Forest management practices such as logging are an example of this approach, where technology can automate and optimize harvesting processes. At the same time, a similar narrative of human-centric problem solving can be present in initiatives to replant forests or maintain biodiversity through technological interventions. For example, while forest restoration involves many site-specific relations between species across spatial and temporal scales, digital technologies that support such objectives (e.g., carbon accounting, landscape planning, or planting tools) advance a central role for human participants to further optimize these multispecies processes. Participation, in this context, usually involves those humans who can oversee, manage, and intervene within technological forest initiatives. Yet these practices routinely overlook other human and more-than-human forest relations.

This article asks how to unsettle participation by working with pluralistic and more-than-human relations with and within forests. *Unsettling* refers to a process of disrupting conventional processes and narratives in conversation with decolonial scholarship that aims to decenter humans and their most dominant epistemologies,[4] as well as constructing alternative narratives that propose new approaches to engage with participatory practices. By focusing especially on contemporary digital forest initiatives that attempt to contribute to averting environmental change, this article seeks to unsettle prevailing notions of participation that center on certain humans. We ask: Who participates in making and remaking forest environments? What propositions for forest practices and inhabitations arise through tuning in to more-than-human entities and relations? And how might such unsettling of participation contribute to more livable forest futures? By problematizing conventional framings of participation, we make a case for more expansive modes of forest participation, where forest environments are (re)made through the participation of many other entities.

By traveling through three different processes of unsettling participation, we analyze what other forms of participation materialize when attending to more-than-human forest relations across technologies, humans, and other forest creatures. The first instance of unsettling tunes in to cicadas as bioindicators to explore how sensing technologies can be recomposed through the participation of forest organisms. The second example of unsettling interrogates a forest that owns itself through algorithms and blockchain contracts with the aim to decentralize forest environments, posing new

4. Rose et al., "Thinking through the Environment"; Wynter, "Unsettling the Coloniality"; Zahara and Hird, "Raven, Dog, Human."

tensions between human-written algorithms and forest ecologies. The third case of unsettling rewrites participation through Amerindian cosmologies, where forest subjectivities are redistributed to reconstitute how digital technologies are conceptualized and used within Indigenous territories. These three unsettlings differently activate and disrupt participation as usually delineated by examining how more-than-human entities together with digital technologies (re)make forests. In other words, these unsettled forms of participation co-constitute and reconstitute forests as expanded inhabitations. We focus on these three examples because they each demonstrate how more-than-human entities differently propose forest inhabitations and futures: The expressive modalities of cicadas transform digital sensing technologies in response to their world-making projects; blockchain contracts and algorithms speculatively attempt to decentralize forest ownership and enable forests to negotiate different futures through digital infrastructures; and Amerindian cosmologies shift ontological dynamics of forest collectives and thereby shape interactions with data and digital technology.

In the following sections, we first consider the formative role that digital technologies play in shaping participation in forest environments. We then consider how participation could be unsettled and further work through three cases of such unsettling. By interrogating such projects and asking critical questions on who participates and how, this article shows that more-than-human realms of forest environments can unsettle participation as usually delineated while drawing attention to who else is involved in making and sustaining forests. We suggest that these pluralistic approaches to participation could contribute to future forests beyond the usual anthropocentric scenarios by engaging with multispecies proposals for how to live in and with forests composed through emerging digital infrastructures.

Digital Participation in Forest Environments

Participation within and beyond forests has become a contested and multivalent term, and digital technologies have further contributed to the remaking of participatory discourse and practice.[5] Digital tools for resource management and spatial mapping are now widely used, where local communities are regarded both as beneficiaries of external interventions and as active participants with different degrees of decision-making power. For example, forest environments have been extensively examined in the form of citizen science, participatory monitoring, or Volunteered Geographical Information (VGI).[6] Participatory digital infrastructures are also installed as alert systems for disaster management and monitoring illegal activity, as in the case of detecting forest fires, or for reporting illegal logging activities.[7] And more recently, a growing number of nature

5. Radil and Anderson, "Rethinking PGIS"; Millner et al., "Politics of Participation."

6. De Longueville et al., "Digital Earth's Nervous System"; Brammer et al., "Role of Digital Data Entry"; Foster, Dunham, and Kaylor, "Citizen Science."

7. Goodchild and Glennon, "Crowdsourcing Geographic Information"; *Forest Watcher* [app], World Resources Institute, 2022 (iOS v3.0; iOS 14.0 or later; Android 3.0), https://forestwatcher.globalforestwatch.org/.

apps, or "Nature 2.0" initiatives, operate through mobile devices, virtual environments, blockchain infrastructures, and social networking that change how certain humans participate in changing forest environments.[8] At the same time, participation can take on a more remote dimension, as users of forest tools and platforms observe and remake forest environments from afar by mapping forest entities, influencing forest planting efforts, or contributing to collective carbon offsetting.[9]

Participation, while materializing differently through distinct modes of engagement and diverse contributors, has become settled as a human-centered project of inclusion. The humans who participate in these initiatives typically include local communities who voluntarily contribute to projects, and sometimes follow technical training to learn how to use digital technologies that contribute to organizing participation. The question of which humans can participate and which cannot is then especially salient in this context. For example, a recent study on the use of alert-based satellite monitoring of illegal forest logging in collaboration with seventy-six Indigenous communities in the Peruvian Amazon, albeit successful in reducing tree-cover loss, also showed that the individuals who were trained to use the technologies gained more perceived authority in local communities, thereby becoming more influential in forest management.[10] In a different context, a VGI research project that aimed to map urban trees in Philadelphia found that urban areas with predominantly white residents also had more usage of the mobile application, thereby drawing more attention to tree data in these affluent neighborhoods.[11] The data of such studies can be limited and unrepresentative when converted into policy decisions on forests, because only certain humans are involved as participants. Furthermore, such digital practices can remake local power dynamics by providing access to technologies and encouraging particular roles for certain local stakeholders.

These examples also show that digital technologies participate in reshaping what forests are, or ought to be. For example, when the absorption of carbon by trees is calculated through cryptocarbon transactions and managed according to market values, forests are expressed in numbers and appear as digital databases. Such data sets can construct new forest realities, for instance through tree planting decisions made in response to carbon accounting.[12] It is critical not only to question which humans are involved as participants or stakeholders in developing and using digital technologies but also to consider how such digital processes are constituting forests differently. Furthermore, it has been observed that online forest conservation campaigns are often aimed at people in the Global North in terms of funding and political decisions, while communities in the

8. Büscher, "Nature 2.0"; Jepson and Ladle, "Nature Apps."
9. Gabrys et al. "Reworking the Political in Digital Forests."
10. Slough, Kopas, and Urpelainen, "Satellite-Based Deforestation Alerts."
11. Foster and Dunham, "Volunteered Geographic Information."
12. Gupta et al., "In Pursuit of Carbon Accountability"; Howson, Oakes, and Baynham-Herd, "Cryptocarbon."

Global South are targeted to implement large-scale restoration projects.[13] Thus, when asking who participates, community forest projects begin to be unsettled to disrupt dominant epistemologies that only include certain humans, and this process demonstrates how different contributors are variously invited or excluded from participation in increasingly digitalized forest environments.

Over the last decades, dynamics in both community engagement and participatory research in forests have been extensively reflected upon, critiqued, and transformed. Some researchers have argued that participatory technologies operate within, rather than disrupt, existing spheres of political-economic power.[14] In other words, participatory practices have been critiqued for reinforcing existing power dynamics and further objectifying forests where conflicts are often mitigated through a process of creating consensus that is typically influenced by the most powerful stakeholders, who tend to promote dominant narratives about the futures of forests.[15] It becomes clear that digital technologies play an active role in shaping negotiations and conflicts about forests in ways that can map onto, amplify, and remake ongoing forms of participation within community forestry and forest management.

Unsettling Participation

The question of who participates in remaking forest environments extends well beyond humans, as forest environments are shaped by many nonhuman participants as well. The problem is that when the concept of participation is limited to the inclusion of certain humans, the negotiations and data that result from these projects tends to remake forests with those humans in mind. This narrow conception of participation ensures that the experiences, relations, and worlds of other humans and entities who co-constitute forest environments can be ignored. Instead, this study foregrounds more-than-human entities to consider how they also participate in negotiating and constituting, as well as proposing and making, forests. More-than-human forms of sociality emerge in this sense, where different entities do not just grow in forests but also make forests.[16]

The notion of more-than-human was articulated two decades ago in cultural geography to propose an increased attentiveness toward the livingness of the world.[17] While the term has surfaced over the last decade to articulate a turn toward less anthropocentric understandings of participation,[18] the precise meaning of more-than-human participation can change depending on who is involved. Within forest environments,

13. Büscher, "Nature 2.0."

14. Radil and Anderson, "Rethinking PGIS"; Millner et al., "Politics of Participation."

15. Agrawal, "Participatory Exclusions"; Thoms, "Community Control of Resources"; Andersson and Westholm, "Closing the Future"; Samndong, "Participation Illusion."

16. Tsing, *Mushroom at the End of the World*.

17. Whatmore, *Hybrid Geographies*; Whatmore, "Materialist Returns."

18. Akama, Light, and Kamihira, "Expanding Participation to Design"; Bastian, "Towards a More-than-Human Participatory Research"; Clarke et al., "More-than-Human Participation."

more-than-human could refer to everything ranging from bacteria to a piece of tree root, or mycelia. Within multispecies realms, this term could include a family of beavers, extinct cicadas, an individual frog, and their multiple relations.[19] Larger entities such as thousands of shrubs, root networks, the weather, a river, or widespread forest viruses also count.[20] Following various Indigenous cosmologies and foresters, forest landscapes are also inhabited by ghosts, spirits, and other barely visible entities that are more-than-human.[21] Material entities such as sensors, mobile networks, or satellite data, can show how agency is located within more-than-human things as well.[22] It quickly becomes clear that the notion of more-than-human is a sprawling and unruly category that can move across complex entanglements.

By incorporating the more-than-human, participation becomes unsettled as a human-only affair to include the world-making projects of other entities. This involves getting to know the relational entities that remake forests, developing a closer understanding of their entanglements with digital technologies, and thinking through the consequences and questions that arise through a renewed understanding of participation. This is important because digital forest environments come into existence through many different entities that are often in tension with one another. The following sections articulate how initiatives in the context of forests and digital technologies interrupt anthropocentric narratives and unsettle the idea that participants in forests only consist of humans. This transformed understanding of participation can move beyond stakeholder inclusion toward attending to the far less structured, more surprising, and barely visible proposals of more-than-human entities in relation to forests and digital technologies. The remaining part of this text unpacks three different processes of unsettling participation in relation to digital technologies and forest environments and shows how more-than-human entities make forests differently.

Unsettling 1: Cicada Songs of Growth and Decay

In June 2021, a community of periodical cicadas burst from soils across the northeastern United States. The event was much anticipated by scientists and cicada fans, because this particular species normally stays underground for exactly seventeen years. After emerging, Brood X, as the trillion-member community is known, only lived for three to four weeks. However, their encounters with humans and technologies continue to propose new understandings and expressions of environmental change. After making themselves widely heard in wooded areas with their infamous mating buzzes, the Brood X males grew quiet and died. The females, having laid hundreds of eggs each, soon

19. Hill et al., "AudioMoth"; Ogden, "Beaver Diaspora"; Westerlaken, "It Matters."

20. Woelfle-Erskine, "Watershed Body"; Tsing et al., *Feral Atlas*.

21. Kohn, *How Forests Think*; Matthews, "Ghostly Forms and Forest Histories"; Kimmerer, *Braiding Sweetgrass*.

22. Gabrys, *Program Earth*.

followed, until all that remained was a scattering of cast-off husks from the newborn larvae that had crawled underground to replenish the forest floor.[23] But another kind of trace was captured by the sensor installed in these spaces: an ensemble of cicadan acoustic expressions, crystallized as digital recordings, which continue to shape new understandings of environmental change.

With their extended dormancies, incredible auditory presence, and trillion-member communities, cicadas unsettle participation by sensing the forest and signaling environmental changes through episodic delays and encounters. All over the world, thousands of cicadas sing of manifold insect life at frequencies and speeds both within and beyond established thresholds of human sense detection.[24] Most notably, today they sing of perpetually changing forest ecologies. Under conditions of climate change and deforestation, these capacities have turned cicadas into bioindicators of ecosystem growth and decay. For example, scientists note that the growth rates of the nymphs living underground have increased under warmer temperatures. Adult cicadas emerge earlier from increased soil temperatures and produce sound with more intention when their body temperatures are elevated.[25] In other words, their songs adapt in response to environmental change.

Cicadas serve as bioindicators, organisms involved in a process of signaling environmental events. Cicadas are among a host of bioindicator species that are studied through and inform technological sensing practices: Lichens are organisms that express air pollution through shifting growth patterns and are observed in NASA's Ozone Bioindicator Garden Project.[26] A camera-recorded patch of Star Moss at the James Reserve ecological study area in California indicates weather patterns through biological aging and morphological changes.[27] In a project that draws on the scientific illustrations of Cornelia Hesse-Honegger, bug deformities capture the rising radiation exposure levels in areas exposed to the Chernobyl fallout.[28] In each of these examples, the organisms express environmental changes and inform new sensing practices or technologies. With regard to cicadas, new technologies—many linked to cicadas' intensive acoustic displays, reaching up to 120 decibels in certain contexts—gave listeners new means to attend to their sounds, resulting in extended understandings of how cicadas and different animal species interact across forest ecosystems.[29]

New forms of techno-science have encouraged an explosion of systematic surveys using different data gathering methods, transforming entomological fields and ways of listening to the forest in the process. In 1902, the US Department of Agriculture used

23. Simon et al., "Advances in the Evolution and Ecology."
24. Sueur, "Cicada Acoustic Communication."
25. Moriyama and Numata, "Ecophysiological Responses."
26. Gabrys, "Sensing Lichens."
27. Gabrys, *Program Earth*.
28. Raffles, *Insectopedia*.
29. Simon et al., "Advances in the Evolution and Ecology."

postcards to encourage people to report cicada sightings, followed by decades of initiatives with phone calls, pictures, and emerging citizen science apps.[30] Bioacoustic recordings now also attend to the changing songs of cicadas as a constitutive "sound of global warming,"[31] and interactive sensing applications offer inventive ways to tune into and encounter possibly extinct cicadas. Andrew P. Hill and cowriters use a digital recording tool called AudioMoth to listen for the presence of *Cicadetta montana*, a cicadan species last sighted in the United Kingdom over twenty-two years ago.[32] This microcontroller works as an acoustic monitoring device that can be attached to a tree branch. The open-source code and cost-friendly hardware are now used by many researchers and foresters to record and identify sound-making species.[33]

While environmental monitoring devices have been around for decades, listening, watching, and gathering data about animals expressing themselves and embodying sensors in the forest, participation can become further unsettled when animals are foregrounded as indicators of forest activities. To this end, the mobile app called Cicada Hunt—a predecessor of AudioMoth—recasts cicadas not only as bioindicators but also as story makers that encourage interactive encounters and decenter the centrality of human participants.[34] This app enables visitors of the New Forest in the United Kingdom to use their smartphones as acoustic sensing devices able to pick up frequencies beyond a human hearing range to locate the possibly extinct cicada.[35] The potential presence of this cicada species is reworked through a gamelike ghost hunt in which participation of the absent cicada is required for the technology to function. The cicada needs to be "potentially present" for this app to operate, which further transforms the insect from an already expressive bioindicating subject to be recorded into a protagonist in charge of surprising the app user with their presence.

In 1962, author Rachel Carson published *Silent Spring*, an iconic alarm call for disappearing insects and against the use of pesticides in agriculture.[36] Now, six decades later, these new cicada songs form a progressively loud or increasingly quiet wake-up call that asks for a response to environmental disruption and inspires diverse strategies of experimental and innovative sensing today. Changing multispecies expressions are initiated by forest organisms in ways that were not anticipated by existing monitoring technologies. Instead, technologies can facilitate more diverse ways of sensing environments and becoming attentive toward individuals or species inhabiting forests. Rather than expanding preprogrammed behavior recorded through sounds, location trackers,

30. Graber-Stiehl, "To Study Swarming Cicadas."

31. Raffles, *Insectopedia*, 318.

32. Hill et al., "AudioMoth"; Pinchen and Ward, "History, Ecology, and Conservation," 134.

33. *AudioMoth* (Open Acoustic Devices), https://www.openacousticdevices.info/audiomoth.

34. Hill et al., "AudioMoth."

35. *Cicada Hunt* (Rogers) [app], 2022 (iOS 1.3.1; iOS 9.0 or later), https://apps.apple.com/gb/app/cicada-hunt/id648038025.

36. Carson, *Silent Spring*.

or cameras until all forest organisms are connected to the internet and emitting data, attending to the participation of more-than-human entities in remaking forests requires technologies to tune in to the expressive modalities of animals themselves, transforming along with the organisms they track, and to become inventive through encounters.[37]

The question of who participates in the intersection of forest organisms, sensors, and humans who monitor environmental changes helps to uncover the different roles that more-than-human entities play in shaping digital technologies. Tracking devices and camera traps can record the behavior of different species and capture environmental change, but the organisms are not dynamically involved in these interactions with technologies. When forest species appear as bioindicators, their own sensing modalities or expressive capacities are recorded by technologies that can be specifically adapted, configured, or reorganized to tune in to emerging ecological events and forest activities.[38] A further unsettling of their participation can occur in interactive encounters where digital technologies more directly relate to the unforeseen proposals of more-than-human entities and become responsive to their world-making projects.

Cicadas' changing songs and ghostly presence can unsettle previous forms of insect participation in environmental sensing technologies because they propose emerging forms of inhabiting changing forests. By producing different sounds, disappearing from our radar, and changing their behaviors, cicadas inspire changing sensing technologies. Their absence of presence shapes human narratives of their possible extinction in ways that are difficult to record.[39] When the trillion-member community of periodical cicada appears after seventeen years underground, scientists, cicada fans, and hungry birds come to experience the "strangest of all the insect dramas," as the event was described in a 1936 newspaper,[40] or, as it was described in 2021, "something from a sci-fi film."[41] This audience is not only drawn in anticipation of capturing food or data. The mysteries of the cicadas' internal body clock, the uncertainty of their appearance in an era of environmental change, and the anticipation of a yet unknown song is what draws a large crowd and can inspire new forms of relating and sensing in response. The new generation of Brood X now lives below ground and may—or may not—surface again in 2038. The forests they inhabit will undoubtedly change over the next seventeen years, and innovations in sensing technologies will respond differently to their changing songs. The ways in which cicadas—and other forest organisms—participate in shaping these technologies in inventive encounters with humans has the power to affect the ways their environments are constituted, experienced, and cared for.

37. Gabrys, *Program Earth*.
38. Gabrys, *Program Earth*.
39. Jørgensen, "Presence of Absence."
40. Berenbaum, "Same Old (Cicada) Song," 15.
41. Moore, "Trillions of Brood X Cicadas," 1.

Unsettling 2: The Forest That Owns Itself

Beyond forest organisms informing and shaping emerging sensing technologies, developments in digital infrastructures can reshape forest ownership structures. Digital technologies such as blockchain initiatives are becoming a part of new ownership structures in forest environments. The Sovereign Nature Initiative, for example, seeks to explore the development of technologies that allow nature to become self-governing. Central to this initiative is the use of blockchain to establish Decentralized Autonomous Organizations (DAOs). Such a blockchain includes strings of code that are run on a decentralized network and cannot be stopped by any single institution.[42] One of the projects that became part of this initiative is Terrao, a forest that owns itself.

Terrao is an ongoing art project that sets up a prototype in which a forest can—in certain ways—negotiate its future. The creators of the project write, "A forest has an exactly computable productive force"[43] because the overall output of the forest can supposedly be precisely calculated in terms of the raw materials it produces. Furthermore, the forest has a role as a service provider because it offers a protected habitat for other species and a space where human visitors can find relaxation. According to the artists, the Terrao project creates value as a forest that owns itself, can be exchanged with other actors, and generates income through which the forest can expand its territory. Crucial to this prototype is establishing a smart contract on the Ethereum blockchain in which the land ownership is signed over to the "non-human actors" as an economic model that manages forest resources. The self-owning and self-governing forest raises the question of what human decision-making processes remain involved in these proposed algorithmic practices.

Beyond the production-oriented understanding of forests captured in this proposal, the question of how the forest can make these decisions is crucial in discussing self-ownership and agency. Actions based on a human-designed algorithm can advance human ideas of forest production and economic value rather than represent a forest's capacity to negotiate its future. However, the project does not further define how the forest can manage itself, which works to further obscure what such algorithms could accomplish. These ideas provoke further questions on the meaning of independent decision-making through algorithms and when a forest would be able to own itself.

Recent discourses in forest restoration and ecosystem services have commented on the use of blockchain and cryptocurrencies for extracting economic benefits through "green grabbing," liquidating forest resources for investment purposes, enabling new power asymmetries between the Global North and Global South, and failing to challenge the actual root causes of environmental degradation.[44] Yet, with the aim to unsettle

42. Sovereign Nature Initiative, https://sovereignnature.com (accessed June 28, 2022).

43. Seidler, Kolling, and Hampshire, "Terra0," 1.

44. Howson, "Climate Crises and Crypto-colonialism"; Stuit, Brockington, Corbera, "Smart, Commodified, and Encoded."

participation by exploring the more-than-human entanglements through a "self-owned" forest, the Terrao project attempts to turn existing human-centered hierarchies upside down toward an undefined forest-centered structure. The algorithm could lead to decisions about which trees to cut and what investments to procure without human intervention, but the algorithm cannot operate outside of its own variables or compute beyond the code and information produced through human-made infrastructures.

The intersection of forest and algorithmic process then raises questions about what an algorithm is and whether it executes intentions defined by humans, or whether other entities can shift the terms and conditions of decision-making. In other words, it remains unclear how the algorithm is shaped over time and who can interfere in its code or perform maintenance updates. When a forest itself becomes the owner of a growth model and makes decisions by executing an algorithm, humans become participants in the forest's projects. This shift from human-centered toward forest-centered economic structures underlines anthropocentric conceptions of ownership within circuits of capital. Through the algorithm, the forest can decide to set up logging contracts with companies to cut down trees when a certain tree height has been reached, and the forest can decide to invest its profits into nature conservation projects carried out by humans.[45] These examples, however, reduce the forest's autonomy to what it can produce as a participant in a capitalist framework and ignores other speculations of what a forest is to itself. It also relies on lines of code to continue operating on behalf of a forest beyond human interference. Speculating about the forest's autonomy beyond these limited economic structures or fixed computational processes could further extend or contrast Terrao's proposal toward other entangled, multispecies relations that remake forest environments.

The smart contract and the DAO prevent human stakeholders, such as potential new landowners or commercial actors, from interfering or claiming control of how the forest could potentially govern itself. At the same time, the forest remains embedded in an economic infrastructure where the algorithm adapts to market values of production and investments. In this sense the project can also be read as embodying a contradiction between the forest's economic growth model and supporting its own dynamic conception of a thriving ecosystem. The forest algorithm seems to be written, developed, and adapted over time through ongoing contributions from forest entities. While such a technological solution to forest self-ownership has the potential to restructure forest management, at the same time research on algorithmic bias has demonstrated how algorithms can hide, speed up, and deepen inequalities through emerging technologies.[46] Contradictions that come up in reflecting on this project include the possibility that, following market-driven algorithms, the forest could understand its own value

45. Fischer, "TERRA0."
46. Gabrys, *Program Earth*.

only according to its number of trees and carbon storage while ignoring other aspects of biodiversity that are needed to ultimately sustain itself. However, such algorithmic logic could encourage forests to self-destruct or displace inhabitants by prioritizing certain ecological processes over others and further obscure human power dynamics written into the code that enables self-ownership. Such more-than-human participation raises the question of how algorithms can recognize a multitude of relations and entanglements that constitute a forest—not just as a collection of trees or a place for carbon storage but also as many different complex processes that can be impossible to integrate into algorithmic calculations.

The forest that owns itself, as an unsettling of human-centric participation, here becomes a forest-centric (or tree-centric) economic infrastructure that provides a disruptive answer to the question of who can participate: certain trees, lines of code, and humans are authorized in the project of more-than-human self-governance. This attempt at unsettling participation reinscribes human centrality through a human-written algorithm. Yet the example also shows that digital technologies create structures that decentralize the decision-making involved in forest management and potentially enable forests to negotiate their futures. A more forest-centric algorithm could further unsettle participation toward different forms of autonomy. Speculative projects that rethink forest decision-making processes help to foreground how other entities propose forests differently. Here, participation is unsettled through digital infrastructures that attempt to administer agency via algorithms. The complexity and multiplicity of forest ecosystems, however, cannot be fully translated into digital decision-making processes. This attempt at reconfiguring participation through a forest that owns itself thus demonstrates how forests require the participation of many different entities to flourish. It further suggests that algorithmic processes might be reworked to better align with the complexity of forest ecosystems.

Unsettling 3: Indigenous Cosmologies and Forest Participants

Besides bioindicator and algorithmic ways of unsettling participation, Indigenous cosmologies have conceived of forests as collectives for thousands of years, where more-than-human entities co-constitute how forests are composed, proposed, and lived. At the same time, digital technologies are increasingly used to curb encroachment on Indigenous territories, particularly in the Amazon rainforest, where deforestation is taking place due to ongoing extractive operations, including illegal mining, logging, and infrastructural development.[47] For example, aerial drones, mobile applications, and online platforms are used by Indigenous Amazon peoples to monitor territories and register disruptive events to alert authorities.[48] By attending to Indigenous practices that involve

47. Urzedo and Chatterjee, "Colonial Reproduction of Deforestation."

48. Slough, Kopas, and Urpelainen, "Satellite-Based Deforestation Alerts"; Macdonald et al. "Indigenous-Led Responsible Innovation."

digital technologies, the potential to unsettle participation emerges through ontological shifts that redistribute subjectivities to more-than-human entities in digital forests.

Conventional practices of including Indigenous voices in participatory initiatives potentially enrich technological developments but also risk erasing Indigenous knowledge when their outcomes do not fully encompass the ontological dynamics that constitute these forests. Rather than conceiving of participation merely as the inclusion of Indigenous voices in decision-making and codesign processes, we consider how an ontological shift can disrupt dominant understandings of digital technologies and participation in Indigenous territories. In these spaces, digital infrastructures that document, process, and predict territorial dynamics are interweaving with Indigenous cosmologies through stories, histories, and cultural relations composed by human and more-than-human entities in forests. By tuning in to Indigenous cosmologies in more detail, it is possible to reshape digital technologies to become more respectful participants within the more-than-human collectives that sustain them.

Many different Indigenous epistemologies propose relational worlds in which territories and more-than-human entities are understood as collectives that can speak, become conscious, and assert connectivity in which humans cannot be separated from other entities.[49] In the South American lowlands, Amerindian perspectivism unsettles participation by positing that all forest entities experience different worlds: the ways that humans see forest entities are profoundly different from how these entities see humans and themselves.[50] Amazonian cosmologies thereby consider that humans and more-than-humans experience worlds from different points of view.[51] The forest comes into being differently through these multiplicities, where the point of view creates the subject, not the object. Amerindian perspectivism suggests shifting the position of the object to the subject by embracing the reflexive perspectives of other entities.[52] For instance, trees can be conceived as having a society, which configures a collective political alterity. Consequently, what Western epistemes call a "forest" is for Amerindian peoples "a society of societies."[53] While anthropologists and Indigenous writers have reflected extensively on Amerindian perspectivism, the roles and usages of technology within Amerindian cosmologies is less well reflected upon.[54] In order to unsettle participation beyond the mere inclusion of Indigenous voices in technological developments, the ontological shift that conceives of forest collectives through multiple perspectives and multiple societies can fundamentally change how digital technologies for monitoring

49. Bawaka Country et al., "Co-becoming Bawaka"; Bignall, *Postcolonial Agency*; Brattland, Kramvig, and Verran, "Doing Indigenous Methodologies"; Lewis et al., "Making Kin with the Machines"; Rose, *Reports from a Wild Country*.

50. Viveiros de Castro, *Metafísicas canibais*; Viveiros de Castro, "Crystal Forest."

51. Danowski and Viveiros de Castro, "Is There Any World to Come?"

52. Viveiros de Castro, *Metafísicas canibais*.

53. Danowski and Viveiros de Castro, "Is There Any World to Come?"

54. Viveiros de Castro and Hui, "For a Strategic Primitivism."

forests are conceptualized, designed, and appropriated by Indigenous communities. Where Western forest monitoring technologies strive to capture and archive data statically, Amerindian cosmologies refer to the past in motion and emphasize relational transformations rather than stabilization of particular categories.[55] The multiple perspectives through which forest processes are generated cannot be observed from a single (human or technological) point of view. This raises questions regarding how mobile applications for forest management activities can include the multiple perspectives of forest collectives while supporting Indigenous self-determination.

In the Brazilian Amazon, long-term conversations and ongoing Indigenous-led projects articulate technologies to be imagined and coproduced as tools to build relations with forest collectives and territories. One such initiative is Alerta Clima Indígena (Indigenous Climate Alert), which is a mobile application coproduced through partnerships between Indigenous organizations, local communities, researchers, and practitioners for Indigenous-led environmental monitoring in the Brazilian Amazon.[56] Over the last six years, several community workshops and local engagements resulted in the formulation of a digital system that both gathers environmental data and enables Indigenous users to register their observations and relations with forests locally. Through texts, pictures, videos, and audio recordings, Indigenous users are documenting local knowledge practices, such as traditional fishing and fruit harvesting, and relations with animals, plants, and other beings, including stories and myths associated with sacred sites and spirits that honor ancestors.[57] These collectives consist of diverse entities that all participate in the creation and processes of forests. In this sense, using digital technologies to monitor forests is not an individual or human affair, but these technologies become instruments with which various entities (such as animals, ancestors, pasts, presents, dreams, and meteorological processes) are understood, negotiated, and rendered legible.

By integrating Indigenous knowledge practices with technological developments, the potential to disrupt conventional conceptions of participation in this example emerges from a more careful attunement to the Indigenous cosmologies that shape interactions with data and digital technology. In Brazil's Roraima state of the Amazon, the Indigenous Council of Roraima adopted the Alerta Clima Indígena application to assist local organization, forest fire management practices, and sociocultural territorial planning as part of their work alongside 58,000 Indigenous peoples from 465 communities.[58] Indigenous experiences and data collected through this application helped communities in this region to elaborate their "Plans for Territorial and Environmental Management of

55. Danowski and Viveiros de Castro, "Is There Any World to Come?"

56. *Alerta Clima Indígena* [app], Instituto de Pesquisa Ambiental da Amazônia (IPAM), 2022 (Android v4.0), https://play.google.com/store/apps/details?id=com.ipam.acibeta&hl=en_GB&gl=US.

57. IPAM Amazônia. "Alerta clima indígena 4.0."

58. CIR, "Conselho Indígena de Roraima," https://www.cir.org.br/ (accessed June 28, 2022).

Indigenous Lands" as part of a national Indigenous policy.[59] This legal approach endorses Indigenous-led technological developments to elevate Indigenous self-determination through territorial governance to protect and value diverse sociocultural relations, languages, epistemologies, and social organizations.[60] Indigenous groups shaped the Alerta Clima Indígena application to encompass the multiple perspectives that co-constitute Indigenous territories in ways that can generate political influence and construct environmental futures. Such Indigenous-led projects suggest the possibility to further develop digital technologies by continuing to work within the more-than-human forest collectives they are seeking to protect and restore.

In this context, technologies become entangled with the cosmologies in which they operate. Digital devices can either work to erase Indigenous knowledge or help to build further relations to sustain Indigenous territories and include diverse forms of participation. By shifting the position of Indigenous peoples from participants in new development initiatives toward self-determining subjects in more-than-human forest collectives, it is possible to dismantle colonial legacies by honoring more diverse relations and building inclusive policies and technologies.[61] Attuning to the Indigenous cosmologies that are foundational to the creation of more diverse modes of capturing, using, and storing forest data can further inspire digital applications in more-than-human forest societies. Such apps could include design elements that enable contrasting forest data to exist simultaneously to avoid knowledge reduction. Furthermore, digital technologies could move beyond decision-making apparatuses that rely solely on human language and involve multispecies communication channels to recognize the political participation of a variety of forest creatures. Beyond informing the design of technology, Indigenous cosmologies also generate more diverse use patterns that express, for example, when forest data should not be captured, stored, or known because of its relations to ancestors, stories, and dangers that exist beyond Western understandings of forest environments.

Pluralistic and responsive approaches to technological development can support Indigenous self-determination by recognizing commonly neglected ontological dimensions.[62] More viable forest futures must include Indigenous-led technological developments that are responsive to the more-than-human collectives and societies that constitute local forests. When territories, ancestors, dreams, animals, humans, and other entities all shape and propose forests, digital technologies are not added on top of these collectives to mitigate ongoing issues, but they have to become a respectful participant within the societies that compose forests. In this way, participatory initiatives move

59. Planalto, "Decreto no. 7.747," http://www.planalto.gov.br/ccivil_03/_ato2011-2014/2012/decreto/d7747.htm (accessed June 28, 2022).

60. Fundação nacional do índio. *Planos de gestão territorial*.

61. Walter et al., *Indigenous Data Sovereignty and Policy*.

62. Ulloa, "Perspectives of Environmental Justice."

beyond attempts to include Indigenous voices in technological developments to join already ongoing forest societies. In other words, they become responsive to the cosmologies and politics that shape them.

Conclusions

Participation provokes unforeseen changes and builds relations that can travel somewhere new. This article analyzes how participatory processes across digital technologies and forest entities exceed the usual human participants and thereby activate the potential for more-than-human entities to propose and remake forests futures. While participation is often generally understood as certain humans inviting other humans to be participants, this text proposes a less anthropocentric or universal understanding where forests can be remade only through the participation of—and relations among—both biological and technological entities. This pluralistic and more-than-human approach disrupts the usual idea of participation as merely including designated stakeholders in forest governance and research initiatives. Instead, it develops a transformed understanding of how more-than-human entities along with digital operations already co-constitute forests and thereby participate in proposing forests.

Instead of rehearsing, repeating, or reproducing the same power dynamics through similar narratives and common themes of participation, this text follows more unfamiliar paths into emerging constellations between other species, digital technologies, and forests. Moving beyond the limited scenarios constructed by certain humans in participatory projects, the three unsettlings all reveal the complex tensions between different entities that are involved with digital technologies in forests. The changing songs and behaviors of cicadas as bioindicators inspire and shape emerging digital acoustic sensing technologies in forest environments. Speculations about forest ownership contracts through blockchain infrastructures reinscribe human centrality through algorithms but also imagine how forests propose different futures of autonomy and cultivation. Indigenous cosmologies ontologically restructure participation where digital technologies join already ongoing forest collectives that sustain territories and attempt to build relations of mutual trust. This article shows that when more-than-human entities become involved as participants in analyzing existing initiatives, new critical questions about the design and use of digital technologies in forests emerge: How could digital technologies become more responsive to changing multispecies sensing networks in degraded forests? What are the limits of human-written algorithms to interact with complex forest ecosystems, and what new realities are they constructing? How do Indigenous cosmologies and collectives inspire digital technologies that involve the ontological multiplicities that sustain Indigenous territories, and how do they disrupt prevailing digital logics?

These processes of unsettling are far from the only possibilities for multispecies and more-than-human participatory thinking with forests and digital technologies. Yet they undo a singular understanding of participation as a form of human stakeholder involvement. These examples change the usual understanding of participation and

illustrate how more-than-human entities help to raise questions and propose different ways of inhabiting forests. By moving beyond limited and conventional approaches to participation, such narratives have the potential to disrupt industrialized and institutionalized forest practices and foreground more-than-human ideas for constituting and using digital technologies to create more livable and just forest futures globally.

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