

BOREAL INTELLIGENCE

Cesar & Lois, Address (Lucy HG Solomon, CSUSM, Department of Art, Media, and Design, San Marcos, CA 92096, U.S.A. | Cesar Baio, UNICAMP, Departamento de Multimeios, Mídia e Comunicação, Campinas, SP, 13083-970, BR) Email: cesarandloiscollective@gmail.com | cesarandlois.org.

Submitted: May 18, 2024

Author Short Bio

Cesar & Lois advance intersections between natural, societal and technological networks. Based in California and Brazil, the collective consists of Lucy HG Solomon and Cesar Baio. The duo has developed a series of projects that propose non-anthropocentric technologies, garnering them the 2018 Lumen Prize in AI as well as selection for Singapore's Global Digital Art Prize biennial exhibition in 2019 and the Mercosul Biennial in 2022. Aiming to reorient AI to the timescales of living systems, Cesar & Lois exhibited in *AI Delivered: Redemption* at Chronus Art Center in Shanghai in 2021 and Zhi Art Museum in Chengdu in 2022.

Abstract

As More-than-Planet artists in residence at Oulanka Research Station in Finland, we studied the bioelectrical signals of forest entities with distinct life cycles, seeking patterns that we think are integral to how the forest thinks. For the experiment-as-artwork we captured pulses of different entities in the boreal forest, from mushroom colonies to trees, mosses and lichens, with each organism's pulse illuminating a sculptural cocoon. Data from the station's monitoring of soil and climate add ripples. The cocoons' electric pulses, something like synapses, originate in the forest's intelligence. Their patterns form the basis for a forested AI, a *boreal intelligence*.

Keywords

Bioart, Artificial Intelligence, art and environment, art and Anthropocene, ecosystemic AI, forest intelligence, bioelectric pulse, biochemical signaling, climate change, anthropogenic evolution

When we enter a forest, we see a multitude of different individuals coexisting. We understand on some level that these individuals are exchanging information in a network in order to fulfill their needs and in response to an external context. The individuals sending and receiving simple data through biochemical exchanges form a complex system from which emerges a range of nuanced behaviors that a forest can exhibit. While we can study this biocomplexity and even learn how this system works [1], our human senses cannot really perceive any of this.

The artwork *Boreal Intelligence* creates an experience of a sentient forest, producing for human senses glimpses of the hidden signaling that makes the forest an active, living network. Bending human-centered technology, Cesar & Lois train AI with nonhuman data to recognize patterns that do not follow human criteria or logic. The artwork is an intervention in the forest, with a number of cocoon-shaped sculptures placed in the forest floor that sense the communications (or biochemical activity) of nonhuman entities through bioelectricity. The sculptures recode the forest specimens' bioelectrical data into light pulses. Illuminating those internal patterns, the pulsing cocoons at different levels of the forest give the viewer a sense of how this nonhuman network makes the forest alive—and intelligent. The series of sculptures embedded alongside forest beings reflect their individual behavior and bio-responses which collectively create an experience of the complexity of forest intelligence (Fig. 1).

Boreal Intelligence involves listening to the signaling of the diversity of life across the forest floor and accessing that complexity to facilitate our comprehension of the forest in another way. The project is an in-situ artwork in the boreal forest with cocoons that wink at different rates, lighting up according to the

Fig. 1. *Boreal Intelligence*, 2023-2024. Forest signaling with sensing apparatus in a sculptural cocoon with custom electronics for More-than-Planet, Finland. (© Cesar & Lois. Photo: Cesar & Lois.)



pulsing of a nearby forest entity—sometimes at a steady pace, as with fungi, and at other times with great pauses, as with lichens. The forest entities have different rhythms and yet they also respond to one another and to external conditions, their bioelectric signaling spiking in response to different stimuli, such as a rise in humidity or an uptake in CO₂. Fungi are particularly sensitive to humidity, as increased humidity communicates to the fungi that it should become active. This metabolic activity accelerates the fungi's signaling, and causes the fungi to emit more CO₂, which is sensed by nearby plants, with a response in their bioelectrical pulses (Fig. 2).

Fig. 2. *Boreal Intelligence*, 2023-2024. Detail of forest intelligence: sensing the bioelectric signaling of fungi. Oulanka, Finland. (© Cesar & Lois. Photo: Cesar & Lois.)



While these chemical pathways seem causal and therefore simple, there are an array of environmental coefficients that organisms respond to, whispering to their neighbors and sounding the biocomplexity of the forest. As we place sensors in forest entities and monitor their pulses (Fig. 3), the asynchronous pulsing becomes an indecipherable pattern to the human observer. Yet silent symphonies are written by these biochemical interactions, and the forest makes sense of the surrounding world with these signals—in silent symphonic thoughts.

Towards an Environmental or Ecosystemic AI

Boreal Intelligence advances an AI oriented to the nuanced relationships of ecosystems and their subparts, and the relationship of those subparts to one another and to climate. Requisite to such an AI is the recognition of relationships among forest entities as an embodiment of nonhuman thinking. As Eduardo Kohn argues, “These nonhuman selves think, and their thinking is a form of association that also creates relations among selves” [2] This project is one node in a series of artworks [3] and articles in which we propose the bending of machines to those relationships and to the logic of complex ecosystems, in a movement towards an “ecosystemic AI” [4].

Within existent technological systems, a preponderance of growth is unplanned and biases persist that are unintended, with extraordinary cultural, economic and environmental inequities resulting from these. Furthermore, AI is increasingly built on human language and logic models, at a time when humans are proving to be incapable of sensing and responding to climate conditions. Emergence and feedback loops are foundational to complexity within artificial and living systems, and by mapping AI to the constituents of the boreal forest, this project advocates for further research into intelligence embodied in ecosystems—as opposed to anthropomorphic artificial intelligence based on human logic and guided by human needs and motivations.

Fig. 3. Adjusting sensors to the pine needles of trees that reach nearly seven hundred years old in Oulanka, Finland. Video still from *Towards a Boreal Intelligence*, More-than-Planet Lab at Ars Electronica, 2023 (© Cesar & Lois. Photo: Cesar & Lois.)



We ponder the collective intelligence of the forest and consider whether this will emerge within the configuration of sensing cocoons. The cocoons installed in the forest pulse with the “synapses” of nearby forest entities, although we hesitate to use language associated with human brains. We are interested in how these environmentally responsive communication patterns and biofeedback mechanisms can inform machine learning—how the signaling patterns created by nonhuman organisms within a forest can form the basis for that learning. While the project does not translate this ecological complexity into human thinking or language, the artwork reveals the web of relationships across nonhuman living beings within the boreal forest, making these discernible to viewers and to an AI.

Limits to Human Perception of Scale

The macro datasets of climate and geological cycles and the micro datasets of plants’ biochemical exchanges are largely incomprehensible to human senses. The time cycles in which we experience the world are vastly different from those that lichens experience. *Boreal Intelligence* merges data from the different layers of the boreal forest with scientific data from Oulanka Research Station’s instruments (Figs. 4 and 5). Forest readings are both intimate and broad, complex and climate-conjugated.

Fig. 4. Instrumentation for the collection of meteorological, atmospheric, radiation and energy conditions at Oulanka Research Station. (© Cesar & Lois. Photo: Cesar & Lois.)



The sensors at the level of the embedded cocoons examine perception and communication according to different species of the forest, on different levels of the forest and yet on a microscale. The data acquired from scientific partners at the station, including local climate and soil readings and planet-scaled observations, provide a dataset that each of those organisms responds to, as well as a contextual dataset for the AI [5].

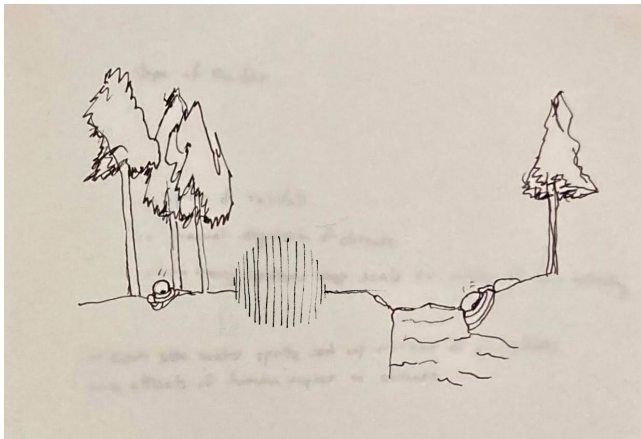
Fig. 5. Machine sensing of climate conditions at Oulanka Research Station, Finland. (© Cesar & Lois. Photo: Cesar & Lois.)



These datasets are beyond human sensing abilities. This scaling of data in the layers of the boreal ecosystem is very different from the information that we perceive on a human scale. While at the research station, we were struck by the importance of longitudinal data for studying the environment and for comprehending climate changes. We wonder how entities at different

levels of the forest respond to these long term changes. We cannot sense in our bodies the gradual shifts in CO² across time, nor can we sense the pulses from different organisms in the forest. Unlike the human heart drumming its beat once per second, these entities may take six hours to repeat a pulse. This is on another scale of sensing and of being. Planetary changes have even longer time lapses, taking place across millennia. Imagine that a planetary intelligence would make one movement in this long timescale, pulsing only once per millennia—not so for fungal intelligence [6]. These timescales are radically different. *Boreal Intelligence* deals with nonhuman timescales, acknowledging what humans are not capable of sensing and making accessible to our senses interactions that make life possible in the forest (Fig. 6).

Fig. 6. *Boreal Intelligence* concept drawing, 2023. Sketch of embedded cocoons in the boreal forest, each corresponding to a forest entity. (© Cesar & Lois. Photo: Cesar & Lois.)



Looking (Far) Back and Figuring the Future

The future is better viewed with a deep understanding of a long-ago past. This prehuman thinking, present in lifeforms that precede human beings on Earth, entails letting go of our humanness. Author Clarice Lispector, in *The Passion According to G.H.*, recalls a prehistorical past, a memory linking the human character to a prehuman sensibility: “A whole lifetime of awareness—for fifteen centuries I hadn’t struggled, for fifteen centuries I hadn’t killed, for fifteen centuries I hadn’t died—a whole lifetime of tamed awareness was now collecting inside me and banging like a mute bell whose vibrations I didn’t need to hear, I was recognizing them. As if for the first time I was finally on the level of Nature” [7].

Later Lispector writes: “And all of a sudden I moaned out loud, this time I heard my moan. Because rising to my surface like pus was my truest matter—and with fright and loathing I was feeling that ‘I-being’ was coming from a source far prior to the human source and, with horror, much greater than the human” [8].

G. H. faces a cockroach, which one might presume is the source of her horror, yet the horror is because this other being is “much greater than the human.” In *Boreal Intelligence* and in the ideal of an ecosystemic intelligence we contemplate intelligence much greater than that of humans, and for that we identify a source similarly “far prior to the human source.”

That source is a forest. Kohn maintains that thinking is not restricted to humans but is in fact linked to life’s proliferating patterns. It is through these patterns, he explains, that forests

think: “In a tropical forest teeming with so many forms of life these patterns proliferate to an unprecedented degree. To engage with the forest on its terms, to enter its relational logic, to think with its thoughts, one must become attuned to these” [9]. *Boreal Intelligence* is a study of the forest’s patterns, an opportunity to contemplate forest intelligence and at the same time an attempt to attune AI to the forest score, taking in the whispering pulse of moss and the steady murmur of mycelia, the pine’s slow ticking and the beat of lichens, though these barely mutter (Fig. 7).

Fig. 7. Lois selects a pine for one of the sensing cocoons for *Boreal Intelligence*, Oulanka Research Station, Kuusamo, Finland, 2023. (© Cesar & Lois. Photo: Cesar & Lois.)



To comprehend the world as a forest does, Kohn shifts the thinking being from the individual to an “ecology of selves,” which includes humans and the living (and no longer living) beings of the forest [10]. An artificial intelligence that thinks like a forest, like a boreal forest, would likewise include an ecology of selves, each responsive to those many others, living and nonliving—as fungi and so many beings of the forest floor are apt to do, composting neighbors and becoming homes for others. Like Kohn and Lispector, we too strive to move beyond the human, to peer into the past and to the future at the proliferating patterns of a complex web of life [11] [12]. We strive to think like the forest—to think in the way of a boreal forest (Fig. 8).

Fig. 8. Cesar & Lois in the boreal forest. Video still from *Towards a Boreal Intelligence*, More-than-Planet Lab at Ars Electronica, 2023. (© Cesar & Lois. Photo: Cesar & Lois.)



Acknowledgements

Boreal Intelligence was made possible through a Meander-Boreal Forest lab and residency as part of More-than-Planet, in partnership with Northern Photography Centre in Oulu, Finland and co-funded by the Creative Europe program of the European Union. Oulanka Research Station is a veritable collaborator as well as host to the project's development [5]. Artist and naturalist Antti Tenetz, project manager and one of the curators of the More-than-Planet project at PhotoNorth, was crucial to our understanding of the forest. He was also a technical, conceptual and river guide. More than most humans, Antti thinks like a forest. In his role as guide, he was aided by PhotoNorth producer Taija Jyrkäs, who shared with us specialties of the region, including cloudberries.

Towards a Boreal Intelligence was previewed at Ars Electronica 2023 in the More-than-Planet Lab. *Boreal Intelligence* premieres as an installation and AI prototype at the Northern Photography Centre in Oulu, Finland in Fall 2024.

References and Notes

1. M. F. Allen, W. Swenson, J. I. Querejeta, L. M. Egerton-Warburton, and K. K. Treseder. "Ecology of Mycorrhizae: A Conceptual Framework for Complex Interactions among Plants and Fungi." *Annual Review of Phytopathology* 41 (2003): pp 271–303.
2. E. Kohn, *How Forests Think: Toward an Anthropology Beyond the Human*. (Berkeley: University of California Press, 2013): p 224.
3. Our artwork *Thinking like a Mushroom* (Cesar & Lois, 2019—) is a precursor to *Boreal Intelligence*. Other artistic linkages between living systems and AI include our projects *Degenerative Cultures* (Cesar & Lois, 2018—), *Mycorrhizal Insurrection* (2022), and *Hyphaenated Intelligence* (Cesar & Lois, 2024).
4. L. HG Solomon and C. Baio. "An Argument for an Ecosystemic AI: Articulating Connections across Prehuman and Posthuman Intelligences." *International Journal of Community Well-being*, 3.4 (Springer 2020): pp. 559–584.
5. We were supported at Oulanka Research Station by station senior researcher Riku Paavola and resident scientist Juho Lämsä, who introduced us to the station's large sensing installations and their growing datasets. Terrestrial ecologist Johannes Cunow lent us his understanding of the evolution of the forest's underground—its roots and mycelia, the shifting composition of the soil—as well as his imaging of those changes.
6. *Allochronic Cycles* incorporates cycles that reflect the cosmos, planetary time, plant time and viral time, with those time cycles determining the speed of rotating disks of different sizes, and an AI interrupting their rotation based on CO₂ projections. *Allochronic Cycles* (Cesar & Lois, 2021), exhibited at La Jolla Historical Society (2021), *AI Delivered: Redemption* at Chronus Art Center, Shanghai, China (2021–2022), and Zhi Art Museum, Chengdu, China (2022).
7. C. Lispector, *The Passion According to G.H.*, I. Novey and B. Moser, trans. (New York: New Directions, 2012): p 46.
8. C. Lispector, *The Passion According to G.H.*: p. 52.
9. E. Kohn, *How Forests Think: Toward an Anthropology Beyond the Human*: p 20.
10. E. Kohn, *How Forests Think: Toward an Anthropology Beyond the Human*: p 78.
11. Jason W. Moore locates the "web of life" within the global movements of capitalism. His electric talks on the planetary impact of capitalism and colonialism inform how we think about the future of society, "Nature" (a word he doesn't abide), and technology. J. W. Moore, *Capitalism in the Web of Life: Ecology and the Accumulation of Capital*. (London: Verso, 2015).
12. In our 2023 essay in *Field* we reflect on Helen and Newton Harrison's directive to artists that we listen (and respond) to the "web of life." Cesar & Lois, L. HG Solomon and C. Baio, "Cesar & Lois: Listening to the Web of Life." *Field: A Journal of Socially-Engaged Art criticism*, 23 (University of California San Diego Press, 2023).