

Research Report

Audible and Inaudible Ecologies: A media archaeology of trees and natural electromagnetism through embedded listening

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Abstract

In this paper, we present *Audible and Inaudible Ecologies*, a work that explores a natural ontology of radio by drawing upon non-anthropogenic sources of transmission and reception. Reimagining a 1919 paper from the United States military which researched the utilization of trees as organic radio antennas for strategic communications, this project instead uses tree-antennas to transduce naturally occurring electromagnetic waves, often called *natural radio*, which typically originate from lightning impulses. The work is comprised of recordings of natural radio received through trees across Japan and the United States, combined with a 4-channel spatialized reproduction of the sonic environments of each tree, recorded with 1st order ambisonics. Through the act of attentive, embodied listening, *Audible and Inaudible Ecologies* invites the participant to explore the underlying natural foundations of radio and the simultaneity of locality and globality revealed through the inaudible made audible.

1. Radio Ecology

1.1. Pre- and Post-Enlightenment Telecommunication

Telecommunication has long been a dream of humanity, before modern satellite communications, the radio, the telegraph, and even Maxwell's equations for electromagnetism and the discovery of electromagnetic waves. However, there is a notable difference in its formulations before and after the Enlightenment.

Horkheimer and Adorno claim the Enlightenment had "the disenchantment of the world" as its object (?). The utility of nature they describe as 'magic' still held mystery, representation, and the non-fungibility of its material, while in Enlightenment science "the essence of things is revealed as always the same, a substrate of domination;" the uniqueness of the object is reduced to an abstract classification, existing so much as it is ready to be used to further human projects (?). The systematic structuring of nature done by Enlightenment science calls to mind Heidegger's enframing, and is where Heidegger himself places the origin of enframing as modern technology's essence (?).

This difference can be seen in theories of telecommunication and electromagnetism both before and after the Enlightenment. Giambattista della Porta was a 16th century Italian scholar, who proposed at least two methods of telecommunication. One, written in his popular book, *Natural Magic* proposed that by using a lodestone, a naturally magnetized piece of magnetite, and two compasses, one can communicate with a distant friend "shut up in prison" by circumscribing the alphabet around the two compasses (?). He argues later in the chapter that two compass needles touched by the same lodestone both receive that lodestone's particular virtue as contrary forces (?). The force between the stone and the compass needles is called *sympathy*, which can act at a distance and is not hindered by materials coming between them (?). The theory relies on the specific 'virtue' of *this* lodestone, as it touches and forges a sympathy with *these* needles. While this theory is flawed and impossible, as magic is "bloody untruth," the underlying 'truth' of this method is based in specific, non-exchangeable object-object relations and the anthropomorphic force of sympathy between them (?).

In 1700s, however, experiments like Stephen Gray and Granville Wheeler's, which included hanging small boys in the air and passing an electric current through them so that metal is attracted to their fingertips (?), or Luigi Galvani's realization that a sufficiently strong electrical surge can cause convulsions in the legs of dead frogs even at a distance (?). There is now an absence of particularity; the hanging boys, the dead frogs, are now specimens, identical and exchangeable due to their physical electrical properties, "souls made into things." (?).

In the spirit of Enlightenment domination, the advancements made in electricity were simultaneously utilized for telecommunications, such as Giuseppe Bozzoli's proposal for wired telecommunication detailed in 1767, or Samuel Thomas von Soemmering's electrochemical telegraph using the recent developments in electrolysis in the early 1800s (?). The story from here is well known: Morse's telegraph in 1844, the telephone in 1876, and Marconi's first successful wireless telegraphy in 1894 that would become radio.

After electromagnetic waves were theorized and proven in the 1860s and 1880s respectively, they were industrialized into radio at astonishing speed. This leads Douglas

Kahn to claim that humanity had very little chance to experience electromagnetic waves as nature (?). However, there are some cases of humans listening to radio before Marconi, even before Hertz proved electromagnetic waves even exist.

1.2. Natural Radio

In the 1870s, Thomas Watson, assistant of Alexander Graham Bell, spent hours late into the night listening to the mysterious sounds of what is now known as natural radio (?), naturally occurring electromagnetic waves often caused by lightning, such as *sferics*, *tweaks*, and *whistlers*, which can propagate vast distances through Earth's ionosphere and magnetosphere. Sferics, short for 'atmospherics,' are caused by lightning discharges. They can propagate up to approximately 2000 kilometers, and are characterized by crackling sounds (?). Tweaks are sferics which travel along the nighttime earth-ionosphere waveguide, up to half the circumference of the Earth; the bouncing between the ionosphere and the earth's surface disperses the frequencies of the sferic into a metallic ping (?). Whistlers are rarer, created when a sferic travels along a magnetic flux tube of the magnetosphere, landing at the conjugal point of the tube in the opposite hemisphere (?). This journey creates a Doppler-like effect, sounding like a descending whistling sound, giving whistlers their name (?).

In his autobiography, Watson describes the strange sounds that he would listen to for hours late into the nights, as the laboratories half-mile (800-meter) telephone wire was long enough to accidentally function as a long-wave antenna (?). Their descriptions match the sounds of whistlers and perhaps the *dawn chorus*, another phenomenon that sounds like the chirping of birds (?). He theorized these sounds may be explosions from the sun, or messages from another planet (?). Other likely documentation of natural radio listening come from 1894, when British post office workers heard sounds on the telephone during a strong aurora borealis display, connecting these sounds to geomagnetic activity, and mysterious whistling along telephone lines in World War I (?). A researcher at the time correctly hypothesized they were related to meteorological phenomena, but some soldiers claimed "you can hear the grenades fly" (?).

Natural radio is primarily in the Very Low Frequency (VLF) and Extremely Low Frequency ranges (approx. 3 Hz – 30kHz) (?). This means the direct transduction of the electromagnetic waves into audio requires no demodulation and creates a direct audible correlate to the sources.

1.3. The Floraphone

The United States army began an early adoption of radio. One officer, George O. Squier, was particularly foundational to many early army radio systems; he was one of the first United States military officers to receive a doctoral degree in 1893, and he even studied under Marconi himself

in London in 1899 (?). Squier would become the Chief Signal Officer of the Army Signal Corps in 1917, but today he is most well-known for after his military retirement, where he founded the company that would become Muzak (?). What is less discussed about Squier's storied history is his research into tree telegraphy and telephony, what he would later term the *floraphone* and the *floragraph* (for tree telephony and telegraphy respectively).

Squier first noted the usefulness of trees in radio systems in 1904, when his soldiers found that radio equipment that could not properly ground in the dry season California in California began to function normally when connected to a nail driven into a live tree (?). Later, this research was revisited "as a war measure" during World War I (?).

Squier's 1919 paper claimed quick success in receiving trans-Atlantic broadcasts, receiving several wavelengths through a single tree, and even sending a transmission from one tree-antenna to be received by another tree-antenna (?).

The afterword of his paper squarely illustrates the domination of nature critiqued by Horkheimer and Adorno, and reveals a Heideggerian enframing of trees as standing-reserve for human military use. He claims trees "have been pieces of electrical apparatus from their beginning," and they can be considered as "highly organized piece[s] of living earth to be used" for human electrical purposes (?). Trees, Squier says, as once revered by humanity in literature, are now able to further humanity's goals and needs through the global existence of durable and effective antennas, standing-reserve and waiting to be used by humans. A tree is now revealed as a "substrate of domination" (?).

2. Revisiting the Floraphone

The introduction to the practice in this paper came about through the failure of a plant electrophysiology experiment. The computer being used to analyze the signal of a tree was specially designed for AC current audio signals, but electrophysiology relies on the DC current of a system. However, before abandoning the experiment, headphones were plugged into the amplifier of the tree's signal, and two local radio stations were heard playing simultaneously.

Looking for an explanation of this accidental discovery led to finding Squier's research with the floraphone. Considering the integration of nature and radio in Squier's work, it was eventually decided to explore the possibility of receiving natural signals through a tree-antenna, rather than human communications or stations. A VLF receiver was constructed and gradually refined over the course of this project, the final circuit design shown in Figure 1.

The tree is attached to the circuit via a surface electrode placed on the bark and a wire connecting into the filter stage, a high pass and a low pass filter for limiting electrical hum and AM radio interference respectively. Potentiometers for both the pre-amplification and amplification stage allow for precise gain control of both amplifier stages

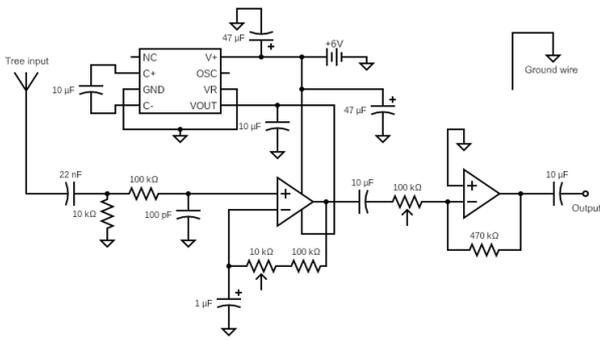


Figure 1. Tree-antenna VLF receiver circuit.

before sending to the output.

The first successful experiment was on July 28th, 2025. Following this test, a total of seven trees across Japan and the United States were chosen and recorded, accumulating recordings of natural radio received through the trees, the local soundscapes surrounding them in ambisonics, and video recordings as a field recording project.

For the recording, the circuit was connected to a Zoom H6 through its headphone jack to record the output. The environments were recorded using the Zoom H3-VR ambisonics recorder, and video was recorded using a Sony EZ-EV1.

3. Audible and Inaudible Ecologies

The field recordings were presented as a listening workshop in an anechoic chamber at the Kyushu University Ohashi Campus. Four speakers were arranged bisecting each of the four walls of the room at a height approximating the ears of a seated listener, with an additional central speaker hanging from the ceiling projecting downwards.

Three workshops were held on November 21st, December 9th, and December 11th, 2025, with three, two, and six participants respectively. The workshop consisted of a 10-minute talk and preparation time, approximately 20 minutes of listening, and a Q&A and discussion period.

The talk covered a brief explanation of natural radio's origins and sounds, their reception through trees in these recordings, and Squier's floraphone research. It also discussed the combination of the audible and usually inaudible (also as local and global) sounds presented in the work and brief recommendations for listening. The talk closed with descriptions of the anechoic chamber, warning that the listening would be held in the dark, and informing participants that they can ask to leave at any time for any reason.

Throughout the three workshops, the listening portion was gradually improved according to the feedback of the participants in each session. The final format included listening to two locations, a recording from each Japan and the United States. The Japanese location was the Kurosaki

Battery Ruins on Ikishima, Nagasaki, chosen for its military history and the gradual overtaking of the ruins by trees and other plants. The United States location was Stockton Dam in Stockton, Missouri, chosen because its history of interplay between the industrial and natural world, as the damming of the Sac River flooded the environment that created what is now Stockton Lake, and the dam is audible in the natural radio recording via the electrical hum of its hydroelectric generation.

The ambisonics and natural radio were first each played separately for a brief period, followed by a longer listening of both sounds simultaneously. After fading out the combined sounds, the process repeated for the second location. The listening was held in the dark to facilitate a deeper focus and lack of visual distraction during the listening experience. The ambisonics were played through the four speakers along the wall, while the natural radio was played separately from the ceiling speaker in order to help participants distinguish between the different sound sources.



Figure 2. Listeners in the anechoic chamber at Kyushu University's Ohashi Campus.

These workshops were trials for a proper exhibition to be held in the future. Because of this, the Q&A time extended beyond the planned time to allow deeper feedback and experimentation with the playback system. Participants also were asked to fill out a response form following the workshop. While most rated the workshop positively, the most significant critique was a difficulty in distinguishing between natural radio and environmental sounds, which was improved in later workshops through changing speaker sources for each sound and by first playing each sound individually, as outlined above. A few participants noted feeling either unfocused or nervous in the dark, but a majority claimed the darkness improved their focus.

4. Discussion

In Squier's research, the floraphone represents the domination of trees for human utility. The reverence he gives to trees is subsumed by his desire to appropriate them for human instrumentality. Through reappropriating the floraphone to listen to natural radio, *Audible and Inaudible Ecologies* reframes the floraphone as a tree steeped in a web of non-human, inaudible energies. The efficacy of trees as antennas as discovered by Squier does not necessitate their utility, this ability can also reveal the foundations of radio as pre-existing the human industrialization of electromagnetic waves, as atmospheric energies that trees have always been attuned to receive.

The interplay of human industrialization and nature is exemplified with the inclusion of the recordings at Stockton Dam mentioned before. Rivers and dams are used by both Heidegger and Douglas Kahn to help explain the relationship between humanity, technology, and the natural world. For Heidegger, the damming of the Rhine River is modern technology enframing the river to exist for us not as its being a river, but as a resource standing-reserve, the hydroelectric dam a challenging-forth of the energy from the river (?). Kahn calls forth the river and the dam to illustrate the speed at which we industrialized electromagnetic waves. He compares the speed "as though rivers had never existed before being harnessed for mills or dammed for hydroelectric production" (?).

The tree by Stockton Dam was intended to provide a contrast to the pure industrialization of nature by Squier and the dam through the reception of natural radio, but the recording of natural radio could not fully avoid the powerful electric generation of the dam, audible in the recording as a strong electrical hum. While the tree was distant enough to avoid the hum fully overpowering the natural radio, a similar drowning out was cited by Thomas Watson. Watson said the sounds he used to listen to at night were completely overpowered by the expansion of the electrical grid for lightbulbs and streetcars (?). This was also noticed during the field recordings for this project, as being too close to an AM radio tower overpowered the circuit's filter and made hearing natural radio impossible, making the presence of AM radio towers a consideration in choosing locations.

In the same way the light pollution of streetlights and billboards in cities blots out the stars, AM radio and vast electrical grids act as a broader electromagnetic pollution making it more difficult to hear the sounds of natural radio. Thus, locality became an important part of this project. The tree, situated in a specific environment, despite receiving signals from up to half-the-planet away, was still dependent on location.

The audible in this project represents the local through the recording of a tree's direct environment, and the distant natural radio, the typically inaudible, acts as the global. The making audible the inaudible here is inspired by Pauline Oliveros's *sonosphere*, which she describes as the

entire sonic envelope of the Earth, beyond what is only audible to humans, but what is also perceivable to "animals, birds, plants, trees, and machines" (?). Natural radio, received by trees as antennas and transduced by a circuit to audible sound is allowing the human perception of a global ecology of electromagnetic energies, lightning discharges and geomagnetic activity traversing vast distances to be received by a living tree.

Oliveros claims that a lack of awareness of sounds can lead to a disconnection from one's environment; "sounds carry **intelligence**," listening can provide information and connectedness to one's surroundings (?). In the listening workshops, the lights are turned off to facilitate focus on sounds, so that listening can embed the participants into the web of local and global sounds, through a deeper focus on environmental sounds that may be familiar (bugs, winds, frogs, etc.) and the introduction of the typically inaudible sounds of distant electromagnetic emissions.

One participant wrote in response to the workshop, "I kind of thought about how incredible it is that there is a sort of invisible net connecting me to the rest of the world. In a sense ov[sic.] everything on this planet being connected and intertwined." In reality, in modern daily life, this simultaneous listening of local and global happens very frequently, so that it is not always fully realized. Phone calls, listening to radio, and streaming music recorded all around the world is an introduction of distant sounds into one's immediate sonic environment. *Audible and Inaudible Ecologies*, however, draws focus to this simultaneity and interconnectedness by revealing it as an ecology beyond the human, based in trees and natural electromagnetism.

5. Conclusion

Audible and Inaudible Ecologies explores a natural ontology of radio through the reimagining of Squier's floraphone, tuning in to natural radio instead of military communications through the pre-existent qualities of trees as biological antennas. By listening to natural radio alongside the surrounding environments of different trees, embedded in the connections of the audible and inaudible, reception of global signals are grounded in locality and particularity.

The work as presented creates a foundation for a diverse future practice. Through future workshops informed by the feedback in this thesis, installation adaptations of the workshop, additional field recordings detailing new trees, and live adaptations to listen to trees *in* their local environments, this thesis creates a robust infrastructure for a continued sound art practice.

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7. Author's Profile

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Born in the United States in 1997, Kota HAYTON is a composer and sound artist currently in the Master's Acoustic Design Course at Kyushu University's Graduate School of Design. He has been a studio resident with the Charlotte Street Foundation in Kansas City (2019-2021) and composer-in-residence with the professional choir KC VI-TAs (2022-2023).

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