

Research Article

Juliana España Keller*

Entering Into a Sonic Intra-Active Quantum Relation with Plant Life

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Abstract: In the speculative research of plant bioacoustics, one enters into a sonic intra-active relation, by humans with non-human beings (plant life), activated through acoustic wave signals emitted by plants to create electronic patterns of sounds composed by humans and emitted by machines. Plants emit sound waves at relatively low frequencies of 50–120 Hz. Experimenting with patching and modulation by tracking these sonic lines of data can indeed lead to unique sonic experiences that tap into the universe's musicology. It is fascinating how we can interact with sounds on such a deep level to create acoustic energy. We are and have always been attached to the universe in a relational processual way. We are all interconnected with plant life vibrating at different internal frequencies. This article focuses on a symbiotic relation between humans and plant life as an acoustic shimmering ecology – to communicate a posthuman, symbiotic understanding of vegetal matter as a morphological force that (re)shapes, (re)affirms our sonic intra-relations to the natural world. This proposition is molecular and metaphysical, as sound matter is of a qualitative multiplicity in the quantum field of listening. By acknowledging ontologically that cosmopolitics brings into relation different practices, practitioners, and the non-human (they assemble in a field of forces and intensities), I argue that there is no sovereign power under which all modes of existence can be organized, and there is no meta-language through which one can master the diversity of all discursive or material practices; but there are intra-relations in which one can get lost in a quantum field of sonic matter by moving into the cracks of the sensorium and the plant biosphere, which includes Indigenous voices. The alterity of plant life is daunting from an eco-feminist materialist position in that relationships are the default state of existence and sonic experiences uncover alternative or additional explanations in a (post)phenomenological world – which is embedded in the stuff of acoustics in the many ways humans hear the world. Thus, to communicate a posthuman, symbiotic understanding of vegetal matter necessitates understanding how sound matter intra-performs through a sonic language – where intra-relations with plant life have complex boundaries for humans. As a creative practitioner, how does one define the mutually beneficial engagement in plant communication with creative musical encounters? Entanglement is messy and a becoming with the universe as a philosophical sonic meditation and worlding. This entails expanding on plants as cosmogonic beings, world builders, and we, perhaps, are the by-products of the lives of our vegetal others.

Keywords: acoustic ecologies, plant bioacoustics, environmental humanities, symbiosis, the biosphere

1 Entering Into a Sonic Intra-Active Relation with Plant Life Inception

I think that's so much a part of the process of creating, ... artistic or otherwise, any kind of creation: listen. To really be open-hearted, and listen to what it wants, not necessarily what you want to say. (Meredith Monk in Reyes, 2020)

* **Corresponding author: Juliana España Keller**, Department of Studio Arts, Faculty of Fine Arts, Concordia University, Montréal, Québec, Canada, e-mail: info@julianaespanakeller.com, juliana.espanakeller@concordia.ca

Entering into a sonic relation with a plant is an ongoing exploration wired into the world of modular synthesis – an electronic music world of the modular intra-acting with the live acoustic wave signals emitted by plants to create electronic patterns of sounds designed by humans, emitted by machines. *Intra-action* is a term coined by American quantum physicist, Barad, and used to replace interaction, which necessitates pre-established bodies that then participate in action with each other. Intra-action understands agency as not an inherent property of an individual or human to be exercised, but as a dynamism of forces. In *Meeting the universe halfway: Quantum physics and the entanglement of matter and meaning* (2007), Barad observes that all designated “things” are constantly exchanging and diffracting, influencing, and working inseparably (p. 21).

Biologists, Monica Gagliano, John C. Ryan, and Patricia Vieira view plants as sophisticated information-processing organisms with complex communication strategies (it is suggested that plants can sense and respond to environmental cues, playing an active role in their own survival and reproduction through chemical languages) which radically transforms our notion of plants as unresponsive objects, ready to be instrumentally appropriated (Gagliano et al., 2017). Plant bioacoustics¹ is an emerging field of plant communication and sound studies research that serves as an example of a behavioural response to specific electronic frequencies of vibrations coming from plants.

In the book, *The Language of Plants, Science, Philosophy Literature*, Richard Karban (Gagliano et al., 2017, p. 3) states:

Plants lack central nervous systems, so the mechanisms involved in sensing and communicating are very different from those of animals. However, plants have been faced with many of the same challenges as animals and they have evolved different systems that provide many of the same functions.

Plants can indeed sense a wide variety of cues that stimulate them on what to do in a situated perspective. Some of those cues in plant perception being, perception of light, chemical perception, perception of touch, perception of temperature, and most significant to this text – perception of electricity and sound in which plants can sense and respond to the sound made by humans. However, there is an ongoing debate between linguists, biologists, and animal behaviourists around what constitutes a *language of plants*. What is clear is that plants perceive so many different kinds of visual, chemical, tactile, and electrical stimuli, and they rely on multiple senses. Some of these senses are primarily used for perceiving information about a plant’s own internal states, whereas other plant life is primarily used for perceiving information about the abiotic environment or other interacting species (Karbon in Gagliano et al., 2017, p. 11).

A discussion put forth below follows the ability of plants to communicate with other living beings in the world in a mutualistic intra-action on all scales of listening with or without the trigger or electronic conduit of technology. I would argue that *becoming with the plant world* aims to transcend the acoustic language of things where all languages are equally valid. The act of translating acoustic language from one being to another grasps the world in a conduit that considers multiple perspectives and voices rather than viewing things through a singular, visually dominated perspective. Exploring different sensory experiences, such as sound, can indeed provide rich insights into the complexities of our surroundings beyond what is typically seen. By attuning ourselves to various languages and modes of communication, we can potentially foster a deeper connection with the world and its diverse inhabitants.

1.1 Becoming With

If something shimmers, it shines with a faint, unsteady light or has an unclear, unsteady appearance. (English translation of “miroiter” | *Collins French-English Dictionary*).

¹ Plant bioacoustics refers to the creation of sound waves by plants. Measured sound emissions by plants as well as differential germination rates, growth rates, and behavioral modifications in response to sound are well documented.

This shimmering space, where imagination and reality intersect. This is where all love and tears and joy exist. This is the place. This is where we live. (Nick Cave in Forsyth & Pollard, 2014).

As a feminist sound and performance artist, researcher, and writer, I am embracing the speculative, the obscure, the intuitive, and the immanent in sound practice with sensory approaches to compose immersive 3D spatial design architecture for audio-visual spaces as sound art, electronic musical scores, and sensory environments with plant life. These research-creation projects are cultivated to make perceptible to the human senses, the slow and subtle sonic intra-relations and other-than human sonic undulations from plant life. From a speculative theoretical perspective, this approach facilitates a shift in perception through the sonic agency with plant life and the musical parameters between the non-human-machine-human relational understanding that plants have always been present and active participants through world-building.

The roots of my research as a sound artist are embedded in the experience of listening to sound matter as an experience in space and is an explicit concern. The listener's phenomenological experience of the acoustic potential of both the room and the instrumental or electronic forces employed in the sound artwork helped me make decisions regarding content, discreet and semantic pitch choices, rhythm, tempo, form through a 3D spatial design architecture.

The acoustic work of experimental musician, John Cage, Electronic Music Composer, Pauline Oliveros, Minimalist Electronic Music Composer, Eliane Radigue and the theoretical writing of Pauline Oliveros, Brandon LaBelle and Salome Voegelin (to name a few) has contributed to qualifying sound matter to describe and convey what is now termed *Quantum Listening* – thus revealing the instrumental, microtonal, electronic forces, and intensities brought into a broader architectural space in a mind-body relation.

The more-than-human relationship with plant life amplifies the growing enquiry into the sonic matter, posthuman thinking, and new materialist concerns, perceptual science capable of generating new expressions in audio-visual works and more robustly connected to the many ways that we are intra-connected to the world through an acoustic perspective – by which sound moves through space in a field of forces and intensities through quantum entanglements, assemblage in the simplest terms.

I am making observations through a quantum entanglement to listen deeply from a minimalist position – the timbre, texture, tuning temperament, psychoacoustics, harmony, *inharmonics* of plant communication, and explore broader theories and texts in the phenomenology of plants (the study of direct experience). I am a part of a performance collective named: CEREUS and my co-composer, Alexandre Pépin, and I are working together to create acoustic ecologies of the Anthropocene as a transversal site for building resilience in ecological continuity, community building, and storytelling in acoustic ecologies. We aim to listen to plant sounds as a mesh of relationships that form an ecology in order to find expression in many different fields that characterize a soundscape, which is a form of bioacoustics. See Figure 1.

1.2 Interactive Art Installation

CEREUS is deeply interested in the creation of a number of interactive art installations designed to ask questions such as: What does it mean to be alive in a symbiotic neo-materialist sensing modality and have agency? How can one slow down through deep listening methods and listen to plant voices that have been looked upon as mere objects? What does it mean to be in dialogue with something that does not share the same language or temporal reality? And once we acknowledge the aliveness of something, what are the ethical implications of that recognition?

This research is geared towards listening and learning from these voices and finding ways to engage with the public with the intention of (re)thinking and (re)situating our relationship with the natural world. Through the art of sonification, we aim to convey audio information or perceptualize data through a spatialized 3D sonic architecture. Auditory perception has advantages in temporal, spatial, amplitude, and frequency resolution that open possibilities as an alternative or complement to visualization techniques for deep listening techniques in an immersive sonic environment.



Figure 1: Rota Festival, Centro Negra AADK, Blanca, Murcia. Note: Cereus in-concert capturing live plants in performance with us. Teatro Victoria, Blanca, Murcia, Spain. © Ana Carucci (2023).

1.3 Methodologies

We use sensors with plants to enter into a sonic intra-relation with a plant as an ongoing exploration wired into the world of Modular Synthesis – an electronic music world of the modular intra-acting with the live acoustic wave signals emitted by plants to create electronic patterns of sounds designed by humans, emitted by machines to present in different in-gallery installations. In our future research development, besides listening and responding to the sonification of plant life, we aim to observe and develop sense phenomena such as soil temperature, soil humidity, particulate matter in the air, light levels, and air temperature/humidity in specific situated 3D spatial audio-visual installation environments.

As impetus for the sculptural 3D spatial architectural form and design of this work, we are inspired to bring a sense of space and depth to our generative audio mixing concepts and use spatial audio design as a perceptual immersive mixing tool; by redefining the way of mixing where you intuitively position objects in spaces and let the acoustic signature of the room build the desired depth of listening directly to the viewer. We wish to create acoustic space (reverberation) that requires recognition of the aliveness of plant life and to place the significance of plants as individual beings and sentient life.

This research also recognizes that different cultures (specifically Indigenous cultures worldwide) do not share the Western human-centric position of plant life and nature but rather see nature as possessing more-than-human intelligence. As Sound Artists, we use technology as a tool to place human and non-human into a dialogical relationship, where both voices are equal despite perceived differences.

The audio data collected by various plant life form the foundation of a number of sonic artworks that materialize these data both independently and with collaborators. The goal of the CEREUS project is to create artworks generated by the different spatial environments that will simultaneously express the complexity and liveliness of plants in a symbiotic relation, allowing the public to engage and co-exist in the immersive experience.

This research is not designed to replace real-life experiences of the natural world, but rather to create the context for perceiving, intellectualizing, materializing, and understanding the liveliness and intelligence embedded within the naturalized other, as a way of initiating a deeper sense of empathy and understanding of the workings of more-than-human minds and beings in the natural world.

1.3.1 The Posthuman Garden

I moved to Andalucía, Spain, during the pandemic after I completed my Doctoral studies in Melbourne, Australia. I live with my retired Swiss husband on a small parcel of land, 20 min outside of the city of Malaga, Andalucía, where I cultivate the earth and I live with plant life in a natural landscape most of the year. As a Canadian citizen, having lived in Canada for 25 years, I work in Montréal, Québec, Canada, during the winter months and I teach full-time at Concordia University. I live between many worlds, so to speak, and I am struck by the words of Sophie Strand (2024) who states:

We are not single selves. We are threads in multispecies webs. Verbs that string together the deep time syntax of the speaking biosphere. Symbiosis drives evolution. Bodily ecotones between species provide the foundation for new landscapes. Life isn't an object. Life lives. And it lives through constant dynamic homeostasis: balancing and rebalancing the earth by sewing different species and landscapes together into a rich ecological tapestry.

When I am home in Spain, I return to the earth and the natural world. I nurture young vegetal matter from seed into mature adult plant beings. I believe in food sustainability and value permaculture. I embrace inclusive visions towards more-than-human beings and create alliances with plants based on empathy and (co)existence through the nurturing of plants and by sensing my own connection to the natural world. This philosophy has spilled over into my creative practice as a sound artist and has afforded me the opportunity to write about what I do and gives substance to my writing practice by composing sound matter into research-creation projects.

I create immersive sonic experiences through speculative imaginative methodologies through a (post) natural garden in which research-creation, and gardening life is a shared space for cultivating ideas through mutual care, empathy, and slow-long term processes. A transdisciplinary approach to gardening is transversal as it feeds a musical sensing, transcending interspecies care by facilitating collaboration, and critical thinking through shared experiences as a multi-species ethnographic approach. This approach not only acknowledges that humans dwell in a world necessarily comprising other life forms but also contends that their entanglements with human lives, landscapes, and technologies must be theoretically integrated into any account of existence.

1.4 Research is Ceremony

What happens when technology is implied in creating sound matter with plants and why would we plant the act of resilience to survive on a collapsing planet? Research is ceremony through indigenous research methods (Wilson, 2020). As an Indigenous researcher, Wilson maintains that indigenous research is the ceremony of maintaining accountability to all our relations, and we must make careful choices in our selection of topics, methods of data collection, forms of analysis, and the way we present information. Thus, my first personal encounter that developed into this remarkable journey began when I captured my first sound recording of the cactus plant variety named botanically *San Pedro Cactus* (*Echinopsis pachanoi*)² in 2022. I was drawn to this night blooming cereus cactus³ because most types of night blooming cereus are fragrant and seductively beautiful, yet their lifespan is so fleeting (Beaulieu, 2022). All are perennial plant life where they natively grow. The San Pedro Cactus is a striking plant. It has a bluish-green hue, distinct spiny ribs, and can grow up to incredible, tree-like heights in the wild. I have no idea how it arrived in my garden. It has been here a long time because it is a mature plant, and the cactus blooms only during the summer months where heavily perfumed flowers invite propagators such as bees, wasps, and other insects to taste, smell, and drink its nectar. The flowers exist for a few hours from dusk to dawn and, over time, I have understood this plant's potentiality and

² This columnar plant becomes 10–20 ft tall if grown outdoors and is hardier than most types of night blooming cereus plants (zone 8). San Pedro cactus is multi-stemmed and fast-growing. Like the “peyote” cactus, it is hallucinogenic when ingested.

³ *Cereus* is a catch-all term describing several types of cacti that only bloom at night (usually only for a single night). The word “cereus” means it is a cactus.

life forces. I have realized that all plant beings were here on this planet far before humans, and their wisdom is beyond our own limited human understanding.

From this personal perspective, vegetal matter knows how to heal sickness, how to mend and restore health, and how to nourish and feed life as Indigenous people have spoken about. They know how to adapt and evolve and have been witness to the ages of life on Earth. Although I am not of Indigenous ancestry, I carry this knowledge into my sound composition research and onto the discursive page as I write this text, almost pre-composing the plant meta-language of a graphic score notation.

2 Quantum Listening

To listen to a piece of music in a *quantum* way is, according to the late feminist composer and American musician, Pauline Oliveros, a heightened state of awareness; it is to connect to all there is by directing attention to what is heard, gathering meaning, interpreting, and deciding on action, changing, and being changed by the listening through rapt attention to space, time, and matter (Oliveros, 2002). After all, is it not important to create a sound composition which represents what you have listened to and what leads us to listening? Where does it take us, and what does it enable? These are “modes of listening” that I learned from American scholar and sound artist, Brandon LaBelle through *The Listening Academy Workshop* (2023) in Basel, Switzerland.⁴

The work of Pauline Oliveros, American, multi-media visual artist and musician, Laurie Anderson, Canadian, Sound Artist, Hildegard Westerkamp, Icelandic musician, Bjork, Black Quantum American musician, Moormother, to name a few sound artists of musicianship and prominent stature in the world of sound and experimental music, exemplify their understanding of quantum listening as a commitment; and it is in our own interest to stay close to listening and to stay close to the ways in which listening brings one within a process of discovery, negotiation, sensitivity, sharing, transformation.

Deep listening, a method of listening with the whole mind-body relation, is to create a critical and creative curiosity, a receptiveness and responsiveness, to what one may hear or encounter, see and feel, and also from what I have understood from LaBelle, is to receive what such listening may give way to, from knowing and meaningful exchange, lazy thoughts, and critical attention to social debate and poetic imagination (LaBelle, 2020).

From the vibrational communing central to “becoming with” (Braidotti, 2006), to the reverberant circulation of views and viewpoints, and to the noisy intensities of creaturely life, *acoustic care* emerges as a craft, a civility, an invitation. It is important to keep our listening going in time, space, and in quantum entanglements. Quantum listening, paraphrasing Oliveros, engages a field that carries the potential for a force. Particles of objects inside a field may change or move. The field of sound can be felt as a potential force. There is active participation by the listener and co-creation of this force between the listening and sounds. In this speculative process, for me, when you shimmer, you shine, although sometimes quite weakly. I speak and write here about a shimmering acoustic energy by which the universe spins its musicology. We are and have always been attached to the universe in a relational processual way without greenwashing all this language through ecocritical discussion.

To me, a shimmer is to describe a small and sometimes weak force on light, on water, in danger of going out but there, all the same, and often beautiful. It is relational to how silk material catches the light and shines in lovely ways. That is a shimmer. How about when you feel like it’s the end of the world but there’s a little

⁴ The Listening Academy is an independent research academy focusing on listening as a philosophical, artistic, social, and somatic issue. This entails a relation to sonic, performative, and ecological practices, sound studies research, and experimental pedagogy. The Academy offers a generative and nurturing framework for researchers and practitioners to engage in collaborative exchange and the sharing of knowledge, as well as workshopping new directions in sound studies and related issues and practices. This includes bringing together individual approaches and work and creating opportunities for material exploration and building new collaborations. The Listening Academy is led and facilitated by Dr. Brandon LaBelle, Berlin, Germany. <https://listeningbiennial.net/academy-editions>. (The Listening Biennial, n.d.)

piece of you that believes things are going to get better? That's a shimmer of hope. Or when you open a door to a dark room and the light from the hall falls into the darkness? That's a shimmer of light. Light is everything for a plant to exist.

In a live performance event, in a human-centric manoeuvre, I amplify electronic signals with electronic music hardware to intra-act with them. Besides the audible sounds from plant leaves and branches as sensors touch them or when the breeze or human fingers sways them, plants can generate their own cacophony of sounds without being tainted by the human intervention of technicity, and the fact remains that plants emit sounds and they “hear” them too in the intra-action between beings and machines (Kikuta et al., 1997; Tyree & Sperry, 1989). In fact, biologist Monica Gagliano speaks about how plants behave differently when placed next to machines that collect data and emit electro-magnetic waves which the plants can detect and affect their behaviour (Gagliano, 2018). This has affected me when I create sound with plants since I am also aware of their presence in the company of my electronic hardware and make a point to feed and nurture them before we play together.

Technicity, in fact, is a term which refers to the relationship between technology and humanity (or humans), and this relationship can either be mutually co-constituted or not. French philosopher, Gilbert Simondon agrees that technicity is undertaken as a result of the relationship among technical objects and humans in that they are both part of a coevolving and continuous process (neither dominated by man nor by digital objects). This process goes from the level of the elements to the level of individuals, and thenceforth to the level of ensembles (Simondon, 1980, p. 78). Technicity, it is suggested, is thus perceived “as a way in which technical objects exists in the world” (Ash, 2012, p. 190). Simondon (2009, p. 17) states:

Technical mentality offers a mode of knowledge *sui generis* that essentially uses the analogical transfer and the paradigm, and founds itself on the discovery of common modes of functioning—or of regime of operation—in otherwise different orders of reality that are chosen just as well from the living or the inert as from the human or the non-human.

To ponder a machine's functioning and regimes of activity, Simondon (2009) suggests distinguishing subsets and the modes they relate to; further, to understand the machine in its *entelechy*⁵ is to know the state of something that is fully realized; actuality, as opposed to potentiality, is posited in the following statement: “*if one wants to understand a being completely, one must study it by considering it in its entelechy, and not in its inactivity or its static state*” (2009, p. 19).

In other words, the technical object in its functioning as an apparatus that needs to be well understood in its sum of parts.

According to Karen Barad's *slit theory* experiment, to describe what is *a wave* and what is *a particle* or what *a particulate* does begs the question as to whether it has *an identity* in its own self or depends on certain kinds of measurements and arrangements. Sound matter, I would argue is therefore neither a wave or particle or rather it is a wave and a particle at the same time depending and contingent upon the apparatus and the arrangement – so what you are and what am I depends on the arrangement of matter in the universe. The other things that are beyond our measurements spill outside of the language relation in a processual world. It can be argued that the acknowledgement of the study of humans–machines–nonhumans is one that, for the most part, assumes a species hierarchy in most scientific realms, rather than a field of similarities and differences.

2.1 The Cracks in the Sensorium

Cosmopolitics is now the common situation for all collectives. There is no common world, and yet it has to be composed, nonetheless. (Bruno Latour, 2004)

⁵ *Entelechy* (from Greek *entelecheia*), in philosophy, that which realizes or makes actual what is otherwise merely potential. <https://www.britannica.com/topic/entelechy> Accessed 24 March 2024.

Cosmopolitics, a conceptual framework that acknowledges more-than-human beings as active agents rather than mere objects outside of human society, has been made visible by science studies theorists such as Haraway (2012), Latour (2004), and Stengers (2005). In the journal article, “Cosmological Deixis and Amerindian Perspectivism” (de Castro, 1998), a widely noted ethnographic exploration illustrates the pragmatic relations of the Indigenous Amerindian communities whose engagement with other species de Castro categorizes as a form of perspectivism.⁶

This critical text encompasses an understanding that the world is populated with perceptions of reality from distinct points of view supported by corporeal diversity. Other-than humans are documented as being infused with spirit, according to Indigenous knowledge keepers. Amerindian perspectives see animals, creatures, critters, and plant life as persons. This specific cosmology is geographically and culturally also situated in Amazonian cosmologies as an epistemological approach that is useful to explain how cosmopolitics points out that humans do not go into conflicts with their perspectives on things; they go into them along with the non-human things that make them act (Latour, 2004). In this modality, personification, one can argue, assigns human-like traits to non-human things, including inanimate objects, ideas, or animals.

In the eco-political cosmos of plants, notes the Belgian philosopher, Isabelle Stengers (2010, p. vii), humans and nonhumans emerge as an integrative practice for navigating our fractured landscape of knowledge. For Stengers, I propose that this fractured landscape refers to the fissure (or cracks) between facts and values, subjects and objects, nature and society, time and history, or world and representation. These cracks in the sensorium reminds us that by treating plants as objects, aesthetics such as these are modalities that position human behaviour as indifferent, apathetic, and almost hostile. For Stengers (2010), physics has been reduced to a certain kind of physics. Stengers (2010, p. 175) emphasizes: “the triumph over the physics of laws over the physics of phenomena.”

Rather than saying that there are no physical laws, Stengers refers us a more complex picture of the entanglement. Stengers invites us to think with an ecological and historical conception of physics that includes the physics of phenomena and the physics of laws. She proposes that the physics of laws are themselves immanent to the ecological circumstances from within which phenomena intra-act. Therefore, when listening to sound matter generated by humans in an intra-relation with plants, technologies of all kinds – no matter what their use, are dynamic and lively agencies, bringing forth a series of unpredictable constraints, requirements, and possibilities in phenomena that cannot be theorized in terms of their human usefulness alone.

In the book, *Dark Ecology* (Morton, 2016), ecology activist, Timothy Morton, writes: “Dark Ecology shall argue that there are layers of attunement to ecological reality more accurate than what is habitual in the media, in the academy, and in society at large.”

We are, I propose, captured by one another under the influence of musicology, and we exert influence on each other through resonant sound matter that is wrapped up in the event. As musicians and sound artists, I would speculate, we are nuanced through technical assemblages that are composed in a (pre)determined world according to Morton but keep us invested in the layers of attunement that manifest within ecological phenomena.

2.2 The Evolving World of Modular Synthesis

CÍON | ‘sáɪən’ | noun (biology) young shoot or stem useful for sprouting or forming new roots, a descendant of a noble family.
(Instruo Synthesizers, n.d.) (Instruo, Specialist Synthesizers)

In turn, a modular synthesizer or Eurorack is technically an electronic musical instrument that consists of a multitude of different components (modules) that are combined to create electronic patterns of sounds

⁶ It is here I would ask the reader to take note as I have pointed out already in this text that indigenous knowledge is the ceremony of maintaining accountability to their relationships with the land and for researchers to be accountable to all their relations, we must make careful choices in our selection of topics, methods of data collection, forms of analysis, and finally in the way we present information (Wilson, 2020).

designed by humans, emitted by machines. The individual modules are connected via patch cables, knobs, switches, sliders, and patch bays and other electronic sound hardware. Simply put, there are advantages to having a modular system because most modules have a plethora of inputs and outputs that can be patched together in any number of ways to produce a constellation of electronic acoustic indeterminate soundscapes. This can open up more new ways of creating and manipulating sounds than on a traditional synthesizer. Captured samples of plant life are either played live and/or stored on a solid-state device as a plant (seed) bank of differential and distinct inharmonic sound recordings. The modules operate as MIDI controllers, equipping sound artists who play a synth or DAW to intra-act with sonic matter from plants with the help of sensors attached to the leaves or stem of a plant that picks up these frequencies and can be amplified in a live performance to create a simultaneous collective listening.

2.3 Simultaneous Collective Listening

Through modular synthesizers, to intra-act with spaces and places through forms of sound composition and live improvisation is indeterminate and abstracted as the plants behave differently dependent on their physical well-being at the time under different spatial conditions. Speculative inquiry into the behavioural relationship with plants becomes an intimate process of simultaneous collective listening and the decoding of sounds and spatiality by a single human proposes the musical possibility of establishing proximity with the non-human. Relationally, one enters into a symbiotic relationship of being attentive to one life form with the other to arouse the sensory body to the limitations of human perception.

This mind–body relation enters into play where human bodies are closely entangled with vegetal matter embedded within an acoustic narrative. Sound synthesis, I propose, can be particularly suitable for this activation and creating synchronous oscillations in the intra-action. This close awareness or shared experience can create an emotional and affective connection for both protagonists in a live soundscape composition. The vagueness of plant language in its own autonomous existence can be affectively felt, heard by the listener arousing the sensory bodies of both plant life and humans. Through deep listening, a musical experience is then expanded on and modulated with the aid of technology.

Philosopher, Whitehead's (2010) concept of creativity⁷ proposes, according to Australian professor and author, Rousell (2022), “a novel togetherness of creaturely experience where nothing has executive control and everything that happens is the mark of a creative accident.”

In short, paraphrasing Whitehead's “*concept of creativity*” for sensing creaturely relations at the nexus of artistic practice, I argue, can open up a sonic field of creative activity that I propose generates novel musical contrasts, and modulates intensities of experience in acoustic soundscapes.

2.4 Transcendent Waves

Listen to everything until it all belongs together, and you are a part of it. (Oliveros, 2010)

For me, intra-action is the foundation of listening and creativity through my on-going and past academic research. Through the concept of biophony, the collective sound of vegetal matter amplified in each given environment refers to a component of the soundscape (Laschimke et al., 2006). In this more-than human conduit, one can analyse how a plant behaves and what we learn from the transcendent waves of their way of

⁷ Whitehead's philosophy emphasizes the elements of becoming, change, and novelty in experienced reality; it opposes the traditional Western philosophical stress on being, permanence, and uniformity (Whitehead, 2010).



Figure 2: The Cereus cactus flower. Note: The Cereus cactus flower is sending biofeedback which is feeding the Arturia Microfreak experimental hybrid synthesizer with midi data. ©julianaespanakeller (2023).

living. From a human perspective, we are all connected by hearing, listening, and the scientific consensus of “translation.”

2.5 Methodology

In concert, the captured recordings of the soundscape/s reflect crucial moments from which “getting lost” in the electronic acoustic waves reflects how responsively we play in responding to plant sound data – offering inputs to be interpreted, reflected upon, that merit a speculative inquiry. Philosophically, by applying the notion of audio patching cables as *wander lines*, I see these sonic conduits with patching cables as “errant”⁸ in the way that inspired French philosopher Felix Guattari in his formulation of “lines of flight” (Guattari, 2015). British scholar, Colman (2011) states: “*Closely linked to Deleuze (and Guattari’s) concepts of ‘multiplicity’, ‘experience’ and ‘rhizomatics,’ the concept of ‘affect’ should also be considered in relation to the concepts of ‘arborescence’ and ‘lines of flight.’*”

Situated as part of the Deleuzian and of *becoming*,⁹ the molecular thresholds of bodies and things as events are described by Deleuze in terms of affective happenings; occasions where things and bodies are altered (Colman, 2011). Further, in *Intensive Science and Virtual Philosophy* (2013), Manuel DeLanda describes the line of flight as an operator that transcends the actual and ascends to the virtual (Figure 2).

⁸ *Errant*, adj. can be described as uncontrolled motion that is irregular or unpredictable. <https://dictionary.cambridge.org/dictionary/english/errant>. Accessed 25 March 2024. (Cambridge Dictionary, n.d.).

⁹ *Becoming*, in a neo-materialistic sense results from relationships between multiple phenomena. <https://newmaterialism.eu/almanac/body/becoming.html>. Accessed 5 February 2024.

In addition, the notion of sonic tracings feeds this mapping process to the processual work of the French philosopher, Fernand Deligny whose conviction in “getting lost” is a performative dis/humanism (Deligny, 2016). This refusal to fix/explain/contain biofeedback travelling through a patching cable is proposed here merely an opening of the *acoustic cracks* that resonate in a mutual relation to nature.

Fugitive neo-materialist scholar and Yoruba poet, Bayo Akomolafe, presupposes that *humility* is a way of knowing that refuses to privilege the knower over the known. He goes further to say that humility is a multi-species arrangement in which “knowing is the fragile trafficking of edges and seemingly determinate borders in a rapturous, open-ended, intra-active, mycorrhizal indermi-verse” (Akomolafe, 2023).

We as humans, Akomolafe argues, are part of a sensorium that characterizes a co-emergent, co-reificatory topos of relations – a summoning into co-substantiating intra-actions, a turning with/in together, a topos, shaped by desire and possibility (Akomolafe, 2023). This, I would add in the sensorium, is co-composed as an acoustic ecology of nature that is shaped by our environment, with plants as our beings of co-analysis.

Botanist, author, professor, and member of the Citizen Potawatomi Nation in the United States, Robin Wall Kimmerer (2013), brings a sense of wonder and humility for intelligence found in all kinds of life from the biosphere that we use to name and imagine as inanimate of the natural and scientific world. For sound artists, this qualitative speculation can be extended further by co-composing with plants to their more-than-human life.

In times when onto-political struggles over life itself have become matters of planetary survival, we are at the edge of a wonderful revolution in really understanding the sentience of other beings. Biologists are now able to trace the complex coexistences and interrelationships of microorganisms with each other as well as with plants, beyond the basic facts that they require water and earth to stay alive and are also needed for oxygen. Electromagnetic waves emitted by plants and tracked as musical notes, transcend where matters of desire, agency, feeling, value and concern are, and we propose, are not separable in human and non-human worlds.

2.6 Zoning in and Cultivating a State of Flow

Vibrations sound both heard and unheard, Vibrations both seen and unseen, Infinite Presence, Deep highway rays of communication, With/to the All universe, Even its unknown duality phases. (Ra, 1972)

Through audio emissions, I propose that plants are embedded with quantum-pulsations of physical energy that can quite possibly indicate a transmission of feeling to expose a radically affective ecological aesthetics that extends across all scales and modes of existence (molecular, cellular, planetary, cosmological) through which perhaps, quantum creativity emitted by plants can therefore perform a principal role as a co-composer of sound matter (Milburn & Johnson, 1966). In an expanding acoustic field, plants producing novel patterns of togetherness under shifting environmental conditions may generate new ecological and sensory values of existence. Each event implicates a *novel togetherness*, amongst plants that reverberate across the universe as a vibratory continuum of musical activity. The concept of novel togetherness is expanded on by Whitehead throughout his book *Process and Reality* (2010).

When plants are connected to sensors, ultrasonic vibrations of (20–100 kHz) can be measured. Plants release audio emissions from different organs and at different growth stages or respond therefore to different situations.

As water travels through the plants' *xylem*¹⁰ tubes, which help keep them hydrated, air bubbles will form and explode, generating small vibrations. Previous studies have picked up these waves, but only through devices attached directly to plants. Biologist, Gagliano (2012) states that: “the possibility that plants are much

¹⁰ *Xylem* (as in “vascular tissue”): the woody part of plants: the supporting and water-conducting tissue, consisting primarily of tracheids and vessels (Milburn & Johnson, 1966).

more intelligent and much more like us than most people think – capable of cognition, communication, information processing, computation, learning, and memory” is research that is trying to uphold whether plants can, for instance, learn or demonstrate their own type of sentience. Thus, plants do not perceive or “feel” pain the same way that animals do because they lack a nervous system and brain.

A raspberry pi device PlantWave (Data Garden, 2023) detects slight electrical variations in a plant via two-electrode sensors/clips placed on the leaves. These variations are graphed as a *wave form*, which is translated into pitch messages that play musical instruments. This device measures microfluctuations in conductivity between two points on a plant. The amount of conductivity between these two points is largely related to how much water there is between them. This changes as plants photosynthesize and move chloroplasts around. The variation is then graphed over time, which produces a sound wave. That sound wave is then translated into pitch.¹¹ Then those pitch messages are routed to control instruments such as a modular synthesizer or keyboard. Each note heard is an expression of a change happening within the plant at the moment. The greater the distance between two adjacent notes, the greater the change that is happening within the plant (Data Garden, 2018). See Figure 3.

Accordingly, different plants will produce different patterns, melodies, and, in fact, different leaves within the same plant can produce different patterns. Over time, even those patterns will change. Rather than switching from plant to plant, experimenting with an individual plant and tuning into its shift in patterns over longer periods of time is being tested in this sonic research. In addition to these changes in patterns, there are some instruments that will only trigger when a plant displays an especially high amount of activity. This is a sign of a significant shift in activity of the plant being activated.

There are no two plants that produce exactly the same patterns. In fact, no two leaves within the same plant produce the same patterns. From an ecological perspective, each plant seems to be tuned to a frequency that most serves its survival. For example, when a plant is threatened, some plants will release a toxin in their leaves when they hear another nearby plant being munched on by a caterpillar. A study from the Linnean Society of London has shown that when Acacia trees are being eaten, they release chemicals that signal to other Acacia trees to produce toxic tannins on their leaves. Interestingly, free-roaming giraffes were observed avoiding eating from downwind Acacia trees, suggesting that they could detect the airborne chemicals and knew the trees were toxic (The Linnean Society, n.d.).

In another significant discovery, plants can also communicate with certain animals to defend themselves. When corn is being eaten by caterpillars, it emits a chemical distress call that attracts parasitoid wasps. The wasps then attack the caterpillars by injecting them with venom and their eggs, so the caterpillars are consumed from within by the hatched wasp larvae (ScienceDaily, 1999). In summary, plants can sense when nearby plants are being attacked and release toxins or send signals to other plants and animals to help defend themselves, demonstrating a form of plant intelligence and communication (Schlanger, 2024).

Plants defend themselves from predators through various mechanisms like mechanical defences, chemical defences, and indirect defences. Mechanical defences include thorns, spines, and hard shells that deter herbivores by causing physical damage (War et al., 2012). Chemical defences involve the production of toxins like alkaloids and glycosides that are toxic to animals ingesting them. Indirect defences include releasing volatile compounds that attract natural enemies of herbivores like parasitoids, which eventually kill the predators. These defence strategies help plants survive in a world where they can’t move away from threats that are all around them (LibreTexts Biology, 2022).

Although plants have the capacity to respond to sound, there is insufficient data supporting them listening to and responding to their own sound waves, although this is currently being challenged by many scientists (Data Garden, 2018). As slight fluctuations in the conductivity of the plant with electronic sensors are graphing these fluctuations as wave forms, translating them into pitch, those pitch messages are translated. Therefore, a plant does not necessarily sound like a specific harmonic but through modulation amplifies their power through acoustic technology and sonic tracing. The electronic circuitry used is the same as that which is

¹¹ *Pitch* is the quality of a sound governed by the rate of vibrations producing it: the degree of highness or lowness of a tone. <https://www.britannica.com/art/pitch-music>. Accessed 1 October 2023 (Encyclopaedia Britannica, inc., n.d.).

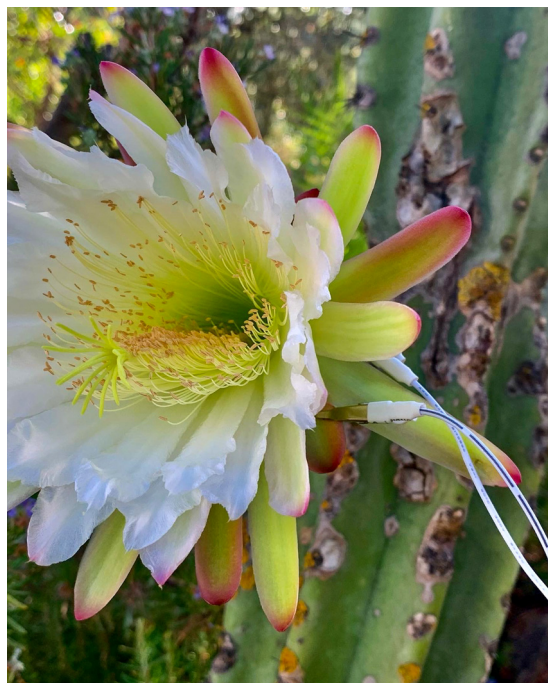


Figure 3: An example of a Cactus that grows in my garden in Spain. Note: The electronic clips attached to plant life detect slight electrical variations in a plant via two-electrode sensors placed on the leaves. From my garden in Spain: *Cereus*, (San Pedro) ©julianaespanakeller (2023).

used in a lie detector. The device is called a psychogalvanometer, and it measures galvanic resistance over time (Farlex, n.d.). Lie detectors were first applied to plants by Plant Scientist, Cleve Backster in the 1960s. Backster claimed that his experiments showed evidence that plants not only respond to physical and chemical stimuli but also are capable of knowing the emotions and thoughts of entities around them. This perception of plants became known as the Backster Effect (Backster, 2003).

2.7 Plant Life is our Motivator in an Acoustic Ecology

As we modulate plant life through the sonic tracings between live vegetal entanglements and the human world, intra-action should be understood as bidirectional as well as errant: how are humans listening and, through listening, intra-relating with our environment; and how is our sonic environment calling upon us, triggering us to act and react? Within sound studies, there is a reservoir of sound possibilities, sonic instrumentation, thereby, for us, modulating vibrational effects. The aim of this article is to cultivate a mediated relationship between human-machine-non-human beings in their environment as a becoming where learning occurs when carefully chosen experiences are supported by philosophical, metaphysical reflection, and through participatory musical synthesis.

From an evolutionary perspective, the reception and processing of quantum energy embedded in sound waves is advantageous, as co-composing with plants allows us to try to experience how and why plants sense sound in their environments. Key questions clearly reside in the information a plant carries, which is slowly unfolding through plant science. By attributing plant characteristics to plants as Kimmerer and Wilson share from a more Indigenous perspective, what is troublesome is to suggest that plant matter has no consciousness, no awareness, no being-ness at all. This denial of personhood to all other beings is increasingly being refuted by science itself and being (re)evaluated, (re)generated as plant intelligence.

This potential upholds an ecological awareness that forces us to think about a (re)worlding and (re)wilding or a “third landscape” as a radical vision of what ecological thought can be (Clément, 2004). French, Landscape

Architect, Gilles Clément asks us not to seek nature in remote mountain tops, but find it instead in the midst of our cities and suburbs. He asks us to observe degraded built landscapes, leftover land plots, suburban yards, old, cemented parking lots, municipal drainage channels; this also reminds me of the plants that we keep in our city flats.

We are asked to observe these living beings not as useless remnants but as territories of vast potential. We pass them every day; their ordinariness is what makes them special, and they are embedded in the fabric of lives, shaping our most recurring images of nature. Clément calls these fragments the Third Landscape, the sum of all the human-disturbed land through which natural processes still occur. As sound artists, looking for plant species that thrive in these kinds of environments is enlightening. It helps us to look at our cities with fresh eyes, by (re)vising our attention to plants through horticulture and ecology, to work with plant species that are classified as weeds – those plants species that usually crowd out cultivated plants – and propose to listen to these plant beings, which are thriving in obscure and harsh conditions, and capture what they are telling us.

In an era of climate change, the variety of species that grow in these spaces and how they interweave to form a dense carpet in our immediate field of view in the urban landscape is to populate or enter through the cracks of the sensorium. Understanding plant life as communities of compatible species that cover the ground in interlocking layers is vital. What can plants tell us about (re)silience and hope, as we (re)establish our connections to non-human beings whose life forces are thriving in the biosphere?

3 Conclusion

I argue that the art of quantum deep listening to plants can open up a myriad of philosophical thought through the language and materiality of electronic music. Science and technology refine our ability to see and extend our senses into many fields. Indigenous ways of knowing, paraphrasing Kimmerer and Wilson, verbalizes that we know a thing when we know it, not only with our physical senses, with our intellect, but also when we engage in it as explained by Simondon and Stengers.

What Pauline Oliveros meant by quantum listening in space, time and matter, proposes that sound matter entangles us through listening, through sonic tracings and errant lines of flight, as discussed through Deligny, Guattari and Akomolafe. From this speculative and bio-acoustic enquiry, I find plant life to have extraordinary capacities in sensing their own environment, responding to their environment, in incredibly sophisticated ways.

The science, although somewhat limited in its ways of defining what is considered to be outside of the laws of physics (as, for example, explained through the critical inquiries of Stengers and Latour and reflected on through the knowledge of Indigenous elders and researchers such as Gagliano), is that plants may have the capacity to learn, to have memory. This is possibly the edge of a wonderful revolution and can contribute to understanding the symbiosis of other non-human life which happens on completely different notation scales, vibrating textures, and tonal differences and is so exciting for all artist practitioners for what we might learn by listening and responding to vegetal entanglements with sonic matter.

The *more-than-human* is an on-going research platform for the sound performative collective CEREUS in the creation of sonic media artworks at the intersection of art, science, Indigenous world views, and technology. The audio-visual works that we create are speculatively and poetically created using a multimodal storytelling as a vehicle for interpreting, mattering, and embodying more-than-human ecologies, with the goal of critically and emotionally engaging with the important work of de-centring the human, even while the viewer is that human. (Re)wilding with sound matter is only the beginning.

Acknowledgements: Independent artists are permitted to use the device known as “PlantWave” publicly with proper credit. This clause is stated in section 1.2.5 of their End User License Agreement. We are using PlantWave as a MIDI controller to play a synth or DAW with our own sounds. In this case, the sounds are owned by the artist. While the MIDI from the PlantWave is being used by sound artists, PlantWave makes no

claim on the MIDI from the device. Accessed October 1, 2022. The SCION Eurorack module is designed through the MidiSprout by Datagarden. <https://www.midisprout.com>. Accessed October 14, 2022.

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