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Mapping Maple Memory

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Mapping Maple Memory: MMM, Sap!

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by

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This project is dedicated to my family,
the maple trees,
and the glass eels.

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Prologue

The maple trees stand, along the road to Montgomery Place, entangled with their surroundings. Woven into cultural and ecological history, and deeply connected to the local soils and geology and the atmosphere. The maple is a harbinger of seasonal change, the maples' glorious red leaves flutter to the forest floor in preparation for rest. In late winter, dripping sap into metal buckets drums the promise of spring's return, and of course, maple syrup. These seasonal changes are visceral, they are bright, and sweet, and we are attuned through our relationship with the maple.[1] We are not, however, in tune with the long term climate cycles, on a geologic time scale. One of the exceptions is that we notice that maple sugaring begins earlier and earlier each returning season. These long term changes are subtle, yet nonetheless present, archived in concentric circles just beneath the bark; each ring is a memory of the growing season. Tuning into these long term rhythms of growth (and decay) reveal how the forest and the climate have changed over time.

This project is an exploration of tree time. (The simple practice of just *being* in the forest affects my sense of time, as it does everyone.)[2] Doing dendrochronology, the study of history through tree rings, reveals how sugar maples react to local climate conditions. The rings hold memory of varying temperature and moisture levels, constructing a story of how trees, humans, climate, and land have all reacted to one another. Artistic practice takes this exploration of sylvan timescales a step further, providing a medium to grapple with or process scientific findings

[1]Throughout this project, I use both the singular "I" as well as the vague and nondescript "we." I use the singular I to identify myself as the scientist, artist, or writer, when describing my personal experiences or beliefs throughout this project through a journalistic style. The use of "we" is twofold. I employ "we" to describe categories into which I fall – farmers and maple sugarers, scientists, and human beings.
[2]Davydenko, Mariya, and Johanna Peetz. "Time grows on trees: The effect of nature settings on time perception." Journal of Environmental Psychology 54 (2017): 20-26.

around climate change.[3] Additionally, art fills the gaps left by anthropocentric language and scientific ontology, allowing for imagination into non-human embodiments of memory.

Across the northeast, sugar maples have experienced declines in growth and elevated mortality, the primary causes being acid rain, pests, disease, and climate change.[4] Climate change in particular raises concern for the future of sugar maple trees, and has become a growing threat to their health. Rising temperatures, change in precipitation, and disruption of seasonal phenological cues result in habitat loss and vulnerability to sugar maple stands, regardless of age, size, and soil fertility.[5] Changing freeze and thaw cycles become asynchronous with the internal clock of the tree, which uses climatic cues for leaf senescence and bud break. As trees react to climate change, forest ranges contract, forcing tree migration further and further north.

The loss of the sugar maple represents a different kind of ecological loss than other plants or animals; we have a deep relationship with the maple. An icon of the northeast, it is connected to human beings through aesthetic, poetic, and agricultural ties. Held together by dovetail joints, the maple is crafted with care to build our kitchen tables and chairs. And it is on our pancakes. As a food item, it is deeply attached to family, love, care, mornings, and health. Considering the maple trees' relationship with the land allows us to create extensive temporal and spatial narratives of symbiotic networks.

Closely examining the maple tree reveals how interconnected it is with a local ecosystem of the more-than-human. Enmeshed with fungal, bacterial, and microbial communities, as well

[3] Alan Macpherson, "Art, Trees, and the Enchantment of the Anthropocene," *Environmental Humanities*, 10(1): 241–256. Accessed April 30, 2023 https://doi.org/10.1215/22011919-4385552
[4] Daniel A. Bishop, Colin M. Beier, Neil Pederson, Gregory B. Lawrence, John C. Stella, Timothy J. Sullivan. "Regional growth decline of sugar maple (Acer saccharum) and its potential causes," Ecosphere 6, vol. 10 (2015): 1-12, accessed April 30, 2023, https://doi.org/10.1890/ES15-00260.1
[5] Bishop et al., 2015

connected with other trees. In *A Tree in a Forest,* a children's book gifted to me by my grandparents when I was six, Jan Thornhill illustrates how a tree's life and energy are cycled throughout the forest ecosystem; showing symbiosis as a matter of both life and death. The maple tree is grounded in the physical space, rooted in relationships with the soils and local geology. The tree becomes home to pileated woodpeckers, redback salamanders, insects, porcupines, lichen, and squirrels. When the tree falls, its rotting wood feeds the lives of future trees, weaving these connections over a deep forest timescale.

A maple tree grows slowly, with each decade contributing to only a centimeter wide concentric ring to its trunk. But, because of this slow growth, everything at a human time scale appears as tiny blips in comparison to the maple's time scale, and even tinier blips compared to geologic time. Deep time, the earths' time scale, happens simultaneously with human time frames, and is visible through the rings of the tree. The concentric circles gesture to the idea of cyclic time, and leave space for the decay that balances growth. Layered atop these long – and oftentimes imperceptible – temporalities are insect life spans and dog years, tree years, and my own timeline as an undergraduate student.

Over the past four years at Bard, studying both environmental studies and art, I have often grappled with how art, science, and agriculture intertwine. This confluence often distills to an ongoing question of how I hold relationships to the land and the beings around me. Because of this, I have built both an academic, as well as personal relationship with the local Hudson Valley ecology and landscape. A major curiosity for much of my life has been the local soils and geology, wherever I find my feet planted. As an extension of this, I like to contemplate how I share relationships with the dirt, and how (by understanding this interaction *as* a relationship) I can come to recognize the soil as beings. I am influenced by my role as a farmer, having planted my feet in the clay soil of the Bard Farm for the past four years. These questions envelop the idea of overlapping time scales; for example, how the soils of the beds that I painstakingly built will continue to feed the Bard community long after I have gone. When it came to the question of which species would be my collaborator in exploring the history of the land and climate, the answer seemed obvious. It had to be the maple tree. The maple as the connecting thread for my project is rooted in my childhood, having grown up in rural Vermont. As a kid, two trees kept watch outside my house; a Sugar Maple on one side and a Paper Birth on the other, as distinct as maternal and paternal sides of my family.

This project is the product of my own entanglement with the maple tree, which serves as a knot-hole view into bigger interspecies and climatic relationships. It is a combination of science, art, and some good old-fashioned farming. It begins, in Chapter 1, aptly titled "Roots," with untangling the roots of ecological philosophy, in order to contextualize the importance of utilizing trees to assist understanding local climate history. Drawing on theory from thinkers such as Timothy Morton, Donna Haraway, Carolyn Merchant, and Lynn Margulis, I begin to view these maples as historical narrators. Approaching the forest from this perspective sets the groundwork for my dendrochronological study, opening the discussion for multiple ways of knowing, rather than operating under a purely scientific ontology. That is, ecological philosophy leaves the door open to a multidisciplinary approach to the history of Montgomery Place, allowing me to grapple with the greater colonial implications of the land on which I conducted my study. In addition to this history, the trees gesture to the deep prevalence of symbiosis that exists within any ecosystem. I use symbiosis in a biological sense, but I cannot help but interpret this in a poetic way as well, in order to consider the ways in which human beings hold relationships with maple trees and the local land. Finally, weaving in the Rara'muri principles of *Iwı´gara* enlivens my understanding of the forest's teachings on long-term symbiosis, with the recognition of air and soil as living parts of an ecosystem as well.

In the second chapter, the meat of the project, the trunk, I lay out the groundwork for and results of my dendrochronological study of the maple trees. According to previous studies, which I summarize in the chapter, changing climate conditions impact sugar maple health and cause growth declines. In order to understand how maple tree growth specifically around Bard's campus has changed over the past decades, I sampled cores from maple trunks at Montgomery Place. In this chapter, I summarize my methods for sampling, as well as my process of cross dating – matching growth patterns between different trees – and creating a chronology – a documentation of the maples' growth history. This chapter takes place between the stand of trees beside the Montgomery Place road and the Tree Ring Lab at Lamont Doherty Earth Observatory, with help from the seasoned dendrochronologists and generous teachers Cari Leland and Neil Pederson.

The third chapter follows the story of sap, from Robin Wall Kimmerer's description as well as a journalistic account of tapping the Montgomery Place trees with the Bard Farm. Sap is a tangible embodiment – through tasting, smelling, and listening – of forest interconnectivity over time. In this chapter, I focus on the relationships trees share with humans and cicadas through their sap. In contrast to the previous chapter, which is centered around the act of gaining information through sight, Sap focuses on the act of listening and smelling. The writing on sound as a perspective into symbiosis with trees is complemented with the act of taking sound recordings, the fruits of which are heard later on in chapter 5.

Chapter 4, Branches, explores the role that place plays in long term ecological relationships and as an extension of this, the role that mapping plays in documenting these connections. Throughout this chapter, I begin to think of branches as maps, a metaphor which also provides a critique of borders and a consideration to bioregions. Place incorporates a human aspect within ecology, and this chapter begins to unearth the site-specific implications of Montgomery Place itself.

Finally, the fifth chapter, the Buds, is the artistic culmination of ecological theory and science through installation. This chapter documents the multimedia installation in the stand of maples at Montgomery Place. The installation is an extension of topics explored in the previous chapters, with themes of place and mapping, temporality, memory, and entanglement.

Roots

Engaging with the ecological crisis evokes grimness and despair, as we witness the decline and impending loss of these sugar maples. I look to the stand of trees, the swaying guardians along Montgomery Place road, keeping watch, holding the earth with their roots. The climate is changing at a rate faster than these rooted pilgrims can migrate. When thinking about the trees' reaction to climate change, measured by their growth rings, my mind wanders into deeper speculation about the forest's collective memory: how do *they* conceptualize, make sense of the changing climate? However, in order to understand the relationship between the maple tree and climate change, we must dig up and examine the roots of our own engagement in these dynamics. Doing so requires rethinking our own place within the forest, and our own place within the anthropocene, through ecological philosophy.

Climate Change

The first step in gaining a deeper understanding in forest-forest climate interactions is coming to terms with its imperceptibility, and wholeheartedly embracing this contradiction. That is, accepting the vastness of climate change and its unmeasurable impacts on both ourselves as a species as well as our non-human planet mates. Unmeasurable, as in it will spiral, triggering climate feedback loops, continuously changing long after humans are gone to experience, let alone quantify it. Hand in hand with the imperceptibility of climate change is our inability to fully comprehend forest interactions. We know, for instance, that trees "communicate" through chemical signals passed through the air, as well as through mycorrhizal networks in simultaneous relationship with these fungi. Yet we are forced to anthropomorphize their actions, for we lack a language to fully describe or understand these processes. The imperceptibility of the world is what ecological philosopher Timothy Morton calls a *hyperobject*, which they define as something that is "massively distributed over time and space" so that humans will never entirely be able to grasp its full essence.[6] Climate change, as a hyperobject, spans vast temporal and spatial scales, which we are incapable of understanding, quantifying, or measuring, even with the help of human frameworks (including science) or technology. Its essence, Morton argues, will forever be beyond our reach.

The first property of a hyperobject is its viscosity, meaning that it is connected in some way to other beings. Climate change is mutually connected to both trees and human beings, through the large-scale exchange of CO_2, be it emission or sequestration. The second property is the idea that it is non-local, not existing in one place. And yet it is everywhere; we can detect its impact on our own localities, but will never fully comprehend climate change at the global level. Similarly, a hyperobject is "temporally undulating": climate change occurs on a scale of time far more vast than we can perceive.[7] Despite its rapid acceleration, climate change is occurring at a geologic time scale – also referred to as *deep time* – and will continue to exist long beyond

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[6] Timothy Morton, *Dark Ecology: For a logic of future coexistence, (*Columbia University Press, New York, 2016)

[7] Nathan, Allen, "Climate Change is a Hyperobject – And that is Why It's Difficult to Understand," Medium, March 22, 2021, Accessed April 30, 2023. https://medium.com/pollen/climate-change-is-a-hyperobject-and-that-is-why-its-difficult-to-understand-6916b6a4b197

human beings as a species is gone. Another property of a hyperobject is its "inter-objectivity", pertaining to the relationships it shares with other objects.[8] It should be noted that these terms are borrowed from Timothy Morton's framework of "Object-Oriented Ontology" (OOO), and only summarized in brief for the sake of this paper, yet are discussed in depth in their book *Hyperobjects.* Climate change becomes detectable through inter-object relationships, flickering in the November heat-wave waterfall dips, or in the haze above the mountains from wildfires across the country. Besides climate change, hyperobjects exist all around us, shimmering in the mundane. They include: the Anthropocene, "all plastic ever manufactured," capitalism, race, and tectonic plates, to name a few.[9]

We can also consider hyperobjects through the anthropogenic systems that cause climate change. The Anthropocene, a term and epoch which I will untangle later in this paper, is not only a hyperobject, but a synergist of *other* hyperobjects, such as the a) technology causing CO_2 emissions, or b) the capitalist frameworks which perpetuate resource exploitation and extraction. One example of technology as a hyperobject flickered during a meeting with my senior project advisor, Beate, when she brewed me a mug of earl gray tea, and placed a small Stirling engine on top of the steeping cup. The Stirling engine is powered by the steam generated from the hot tea, the energy of which incites a spinning wheel. The engine is perpetuated by gas compression between the differing temperatures of the cup and the room. This machine converting heat energy into power is the same mechanism as the steam engine or the nuclear reactor. We sit, watching. We cannot comprehend how this machine on my teacup is responsible for the industrial destruction of communities and ecologies amongst its "progress." It is, of course,

[8] Ibid.
[9] Timothy Morton. *Hyperobjects* (University of Minnesota Press, September 23, 2013).

connected to other oppressive systems, such as British imperialism and colonialism over India, which shimmer in the physicality of my mug of earl gray. We still cannot grasp the vastness of its impact.

Flickering in the Trees

Studying hyperobjects is made accessible through these murmurs and flickers, which is where dendrochronology comes into play. We are able to view climate change through the knot-hole, with the help of the tree's vast scale of time. Tree rings – a collection of memory or an archive – contain information of a surrounding area's temperature and moisture levels, as these variables affect growth. These rings allow us to construct past climates, as well as provide insight into how trees themselves experience climate change. Additionally, the rings, in comparison to our human senses of time and space, reveal the idea that there are multiple temporal and spatial scales occurring simultaneously.[10] Individual rings on a core reveal how that tree grew, providing insights on temperature and rain conditions for a given year. However, by looking at the tree ring through a core, a 5.15 mm cross section of the trunk at breast height, we have only a sliver of understanding of the maple's growth. We can consider climate change this way as well; no matter what climate metric, we will only see a sliver. With Morton's concepts of imperceptibility in mind, our anthropocentric epistemologies are humbled, thus freeing us to take a more playful perspective on the world.

When weaving science into these ontological questions, about the interactions between the trees and human beings and climate change, Donna Haraway's writing rings out, demanding we (as scientists) reckon with our partial perspectives. This term accepts the impossibility of

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[10] Timothy Morton, *Dark Ecology.*

omniscience and highlights the challenge of objectivity, echoing Morton's idea of the hyperobject. Haraway, a feminist philosopher and biologist, critiques Science's habit of perpetuating human exceptionalism, or the idea that humans are separate from other beings.[11] She posits the idea that knowledge can never be objective, yet Western science perpetuates anthropocentrism and human exceptionalism in the illusion of achieving some level of omniscience. She argues that it is impossible to see the world from a neutral standpoint; critical of the idea that "an 'object' of knowledge is a passive and inert thing."[12] That is, we are only able to achieve objectivity when we consider our partial views, the idea that we will only have a small fraction of an understanding of an object. In the case of climate change and its relationship to local sugarbush ecosystems, this means embracing the knot-hole we are looking through, and reveling in it.

On the topic of vision, Haraway pauses, critiquing the supremacy it demands over the other senses. She uses vision as a metaphor for objectivity, with a separation between the seer and what is being seen. Untangling vision from the rest of the senses, she refers to the illusion of the "god-trick," which perpetuates the myth of omniscience. In her words:

> "The eyes have been used to signify a perverse capacity-honed to perfection in the history of science tied to militarism, capitalism, colonialism, and male supremacy-to distance the know- ing subject from everybody and everything in the interests of unfettered power. The instruments of visualization in multi nationalist, postmodernist culture have

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[11] Occasionally, I will capitalize "Science" as a means of distinguishing the institution from traditional ecological knowledge (TEK). That is, science is not inherently tied to capitalism or colonialism, yet it (like mapping) has become a weapon or tool of these systems, especially in the case of its relationship to eugenics.

[12] Donna Harraway, "Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective," *Feminist Studies*, Vol. 14, No. 3 (Autumn, 1988): pp. 575-599 https://doi.org/10.2307/3178066, 591

> compounded these meanings of disembodiment. The visualizing technologies are without apparent limit… Vision in this technological feast becomes unregulated gluttony; all seems not just mythically about the god trick of seeing everything from nowhere, but to have put the myth into ordinary practice."[13]

Haraway describes disembodiment, that removal between the observer and the observed, which is apparent when it comes to the natural world. Haraway goes on to describe the lack of agency as a result of this separation. Accepting situated knowledges and partial perspective, Harraway bridges the gap between the observer and the observed, returning agency to the non-human. This allows us to approach studying something like climate change in *collaboration* with the non-human, rather than asserting dominance or ownership over it. That is, viewing trees as historical agents, rather than an object of knowledge. By coming to terms with the fact that all knowledge is and will be partial, we can reject the idea of a universal truth and open the door to other ontologies. Partial views, these slivers of knowledge, are connected through networks of diverse community understanding. I picture this form of knowledge as weaving a tapestry. It incorporates some level of accountability, which in Haraway's words, "[requires] knowledge tuned to resonance, not dichotomy…"[14]

Recognizing the agency of nature in historical narratives is imperative, as it deepens our own understanding of climate history. This is because trees have a much more vast temporal horizon than human time scales can span. Deep time operates or cycles at a planetary level, including evolution, geologic processes of erosion and uplift, or tectonic migration. The Anthropocene denotes the impact that humans have on the planet; this era of earth time

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[13] Donna Harraway, "Situated Knowledges," 1988, 581
[14] Ibid, 588

experiences humanity as a geomorphic force. Therefore, processes that occur over centuries are happening almost instantaneously. Old growth forests, containing centuries of interconnected ecological communities are cut down by the hour, and industrialized food production systems depletes aquifer reserves faster than they can be replenished. Another way to consider deep time as collapsing is through anthropogenic emissions causing climate change at rates faster than species (including the Maple) can adapt. These human systems, driven by capitalism, ignore the soil communities of fungi, bacteria, insects, and plants, which together weave together to create long term ecosystems. In the context of climate change, writer David Farrier describes the presence of deep time as "not an abstract, distant prospect, but a spectral presence in the everyday."[15] This spectrality is made true by the visualization of tree ring memory, and also appears in confronting the climate crisis, as fossil fuels – production of ancient growth and decomposition – are emitted back into the atmosphere almost instantly. Or, spectral in the case of plastics, which are viewed as disposable, but will outlive us all.

Viewing the world at earth-magnitude and deep timescales is an overwhelming task, which positions the idea of partial knowledge as a huge reassurance. Again, both a humbling and freeing sense. Granting agency to trees allows us to ask them questions. Carolyn Merchant, another influential eco-feminist philosopher, poses the following:

[15] David Farrier and Aeon, "How the Concept of Deep Time is Changing," *The Atlantic,* October 31, 2016, https://www.theatlantic.com/science/archive/2016/10/aeon-deep-time/505922;
Allen Macpherson. "Art, Trees, and the Enchantment of the Anthropocene."

1. What is the world made of? (ontological question)
2. How does change occur? (historical question)
3. How do we know? (epistemological question)[16]

Symbiosis

Opening up narratives to the non-human perspective is important in the context of studying natural history and local climatology. The trees remind us that symbiosis is imperative for survival and resilience, and is embedded within our own evolutionary history – a creation story which is often forgotten.[17] Symbiosis, in its definition, is close interaction between species over long periods of time. It includes a broad spectrum of relationships, from parasitism to mutualism, but at its core, symbiosis is the constant reminder that no species can survive alone. The maple gestures to symbiosis in underground fungal networks , in moss and lichens growing up the bark, and entangles humankind in relationship as well, through the cultural importance of maple syrup. Mutualism is described as an uneasy alliance between two species, and I will further unravel the tension of generosity in human-tree relationships in Chapter 3.[18]

Considering the various forms of relationship with the sugar maple helps tackle Merchant's first question, – what is the world made of? – solidifying the idea that the world is made of symbiosis. Lynn Margulis, in her book *Symbiotic Planet,* presents the Gaia Theory, which is the idea that the earth exists as one superorganism through self regulating feed-back

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[16] Merchant, Caroline, "The Theoretical Structure of Ecological Revolutions," *Ecological Review*, Vol. 11, No. 4, Special Issue: Theories of Environmental History, (Winter, 1987); 265-274 http://www.jstor.org/stable/3984135, 267.
[17] In this project, I am learning from trees, yet the non-human teacher could be any other species, or even the soil. The perspectives of course, would vary, yet the overarching teachings of a requirement for kinship would prevail.
[18] The phrase "tension of generosity" in order to describe symbiosis was lifted from Patty Kaishian's *Queer Ecology.* As mutualism and symbiosis are often romanticized, I find this distinction through wording particularly compelling, and equally poetic.

loops. This hypothesis is rooted in Margulis' discovery of the role that symbiosis plays in prokaryotic cells evolving to create eukaryotes, bacteria, and eventually algae. That is, before branching off, becoming different forms of being such as trees and cicadas and
dogs and humans,
"we" were nothing but cells, bouncing off
each other (1), until they
eventually engulfed one another
(2), becoming something new
entirely (3); Margulis calls this *symbiogenesis*.[19]
This image depicts the process of symbiogenesis in the formation of undulipodia, a eukaryotic ancestor of green algae.[20] Ever since our time in the primordial soup, life (prehistoric, historic, and current) has required symbiosis, yet it is often ignored as one of the fundamental drivers of evolution. Symbiogenesis, as a concept, was not accepted by the more dominant evolutionary pedagogy. In contrast to Darwinian language, which is individualistic and centered around competition, symbiogenesis is grounded in the idea that attraction and cooperation can be a mechanism for evolution.

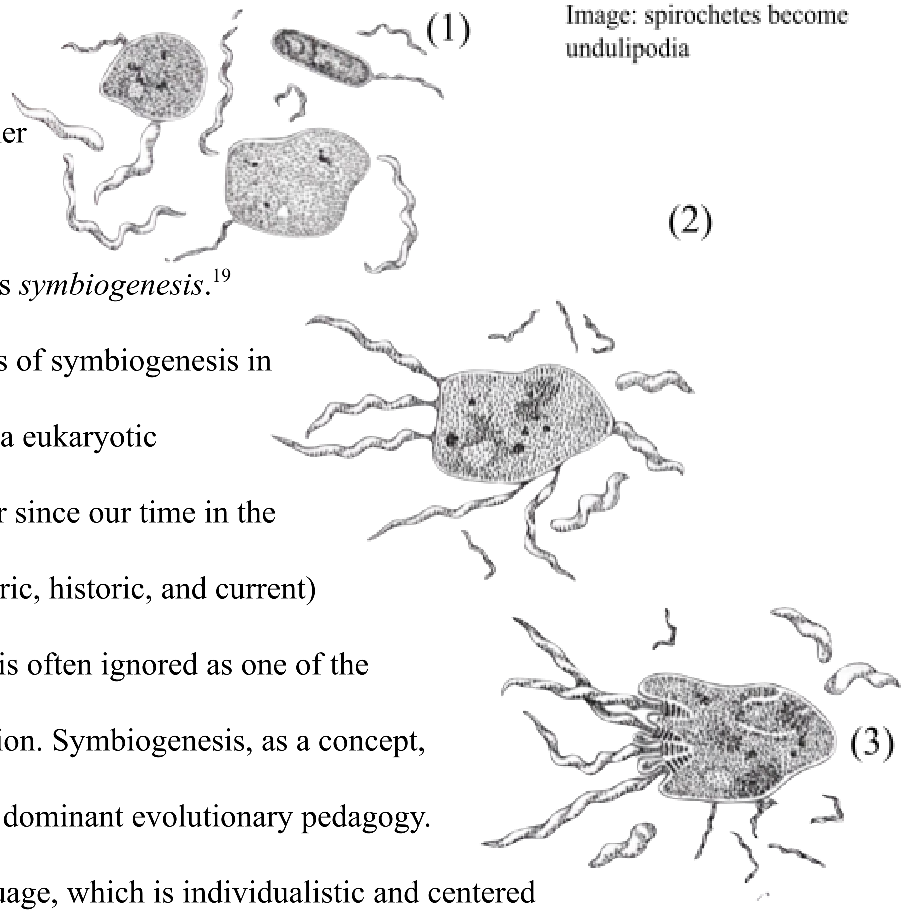

Image: spirochetes become undulipodia

The original occurrences of algal symbiogenesis were so historically distant that there is a great degree of disembodiment between our past iterations of self, making it difficult to call that

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[19] Margulis, *Symbiotic Planet*, (New York: Basic Books, 1998), 35
[20] Ibid., 35

collection of cells (3) in the primordial soup "we."[21] We have no memory of the original merging of cells, and yet symbiosis persists as an essential building block for life. It gurgles in our stomachs, the relationship between gut microbes and cells.[22] For other examples and actualization of symbiosis, we can look at forest relationships, with the basis that these other beings have that kind of narrative agency.

Margulis provides another argument towards non-human agency in the Gaia hypothesis, which is the idea that the world is made up of proprioceptive networks, which is the sense of the self positioned within space. Proprioception is how I know that I am raising my arms above my head, running downhill, or wiggling my toes in the soil. This sixth sense is not only shared with all species, but has persisted long before humans existed, and works to create a global nervous system.[23] It is, according to Margulis, "as old as the self itself."[24] Accepting the idea of non-human proprioception at a planetary time scale provides an underlying foundation for constructing imaginative language around the Maples' experience of climate change or its perceptions of the land. Margulis gives the example of trees releasing volatile organic compounds (VOCs) as a warning, after sensing the presence of a spongy moth attack, something that I observed in the forest I studied.[25] Another visualization for sylvan proprioceptive networks is in crown shyness, which occurs in other forests – often ones with high wind – where trees will

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[21] This sense of distance is what Morton calls "the severing," a definition which I will further untangle later in the chapter

[22] This is the idea that we are all lichens.

[23] Margulis, "Symbiotic Planet", 114

[24] Ibid.,113

[25] Ibid.,113;

An additional example of sylvan proprioception came from the University of Helsinki, where they conducted a study to find that trees are aware of their size, as the birches that they studied adjusted their stem thickness relative to their height.

not let the outer branches brush against their neighbors, creating a jigsaw puzzle pattern in the overstory.[26] Narrating proprioception through maps is explored in *Branches.*

The Gaia theory states that these networks of symbiosis are woven together over vast space and time (all the more reason to look to beings with alternative scales.) Gaia is built upon interconnections across species, a cyclic tie between the living and the non-living via nutrient and energy cycling. In undisturbed forests, old trees die and become nurse logs, supporting the lives of fungal, bacterial, and microbial communities, of detritivorous insects, and mosses. Other saplings take root in the nutrient dense fallen trunks, as life multiplies from the decay.

Root architecture serves as a window into the ongoing symbiosis, in the swellings in tree root tips, where fungal hyphae merge, creating an interspecies network of nutrient, water, and energy exchanges across species. In this way, seemingly dead stumps are kept alive by their neighbors, nurtured through nutrient transfer through these networks.[27] Hidden within mycorrhizal architecture is the breath between what we consider living and what we consider non-living, as tree roots hug the land, and fungi aid decomposition of parent material and decaying organic matter. Through the process of decomposition, the binary between living and nonliving is chewed away, revealing the basis for long-term symbiosis.

Through these processes, all of the living and nonliving weave a relationship with the land in addition to one another. Indigenous Rara'muri principles of *Iwı'gara* breathe life into all

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[26] Emily, Osterloff, "Crown shyness: are trees social distancing too?" *Natural History Museum*, accessed April, 20 2023, https://www.nhm.ac.uk/discover/crown-shyness-are-trees-social-distancing.html#:~:text=In%20some%20forests%2C%20if%20you,is%20known%20as%20crown%20shyness.

[27] Peter Wohlleben, *The Hidden Life of Trees,* trans. Jane Billinghurst (British Columbia: Greystone Books, 2015)

aspects of these networks, describing the kinship that is built through symbiosis.[28] Kincentric ecology is the emergent philosophy of *Iwi'gara* which is the Rara´muri concept of interconnectedness of all forms of life in the Sierra Madres, the land of which the Rara'muri are a part of.[29] *Iwi'gara* unites the physical and the spiritual through the same breath of life; it connects the trees, humans, stones, insects, fungi, and the Rara'muri land, the Sierra Madres. Enrique Salmon describes *Iwi'gara*:

> "Iwı´ is also the word used to identify a caterpillar that weaves its cocoons on the madrone tree (Arbutus sp.). The implication is that there is a whole morphophysiological process of change, death, birth, and rebirth associated with the concept of iwı´. Iwı´ is the soul or essence of life everywhere. Iwı´gara then channels the idea that all life, spiritual and physical, is interconnected in a continual cycle."[30]

Thus, kincentric ecology grants agency to all beings as well as positions human communities as equally connected to the "natural" world. Additionally, kinship blurs the rift of nature and culture. We can look to the forest for examples of this interconnectivity, which comes to life beneath our feet in mycorrhizal networks, revealing the liveliness of soil. Interconnectivity also comes to life in the form of lichen, carpeting the bark, which captures nitrogen from the air and converting it into an accessible form for the plant roots.[31] Rainwater then flows down the trunk, collected by the crown, in rivulets, delivering this fertilizer to the roots.[32] Memories of forest reciprocity are held, then, within the growth rings of trees.

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[28] Enrique Salmón, "Kincentric ecology: Indigenous perceptions of the human–nature relationship," *Ecological applications* 10, no. 5 (2000): 1327-1332. https://sci-hubtw.hkvisa.net/10.1890/1051-0761(2000)010[1327:KEIPOT]2.0.CO;2, 1328
[29] Salmon, *Kincentric Ecology*, 1328
[30] Salmon, *Kincentric Ecology*, 1328
[31] Wohlleben, *The Hidden Life of Trees,* 65
[32] Ibid., 65

This Indigenous worldview realizes the resonance between nature and culture, a binary constructed in Western ontology. Language solidifies this binary, as other cultures, such as Arabic, do not have a separate word for "environment," and American English has no word for the essence of *Iwi'gara.* Additionally, describing non-human modes of "communication" and "memory" in the contexts of forest soil networks and tree rings, respectively, requires some degree of anthropomorphism. Looking at these networks gives us insight into ecological networks, yet once again reminds us of the imperceptibility of it all in our ability to fully translate. Describing these concepts reveals how language fails, calling art into play, in order to portray through alternative mediums what we do not have the words for. In this vein, Margulis writes about the integration of the myth within science; stating the importance of imagination surrounding the unknown.[33] On the origin of life, she writes "... [it] is a mythical concept, not in the sense of being untrue but rather in stirring a deep sense of mystery."[34] She specifically invites myth into scientific writing, yet I would venture that she would equally welcome art within science.

Our language falls short in describing the intricacies of fungal-sylvan reciprocity, as well as the communication that occurs between other beings. We know, for example, that trees communicate with each other both through mycorrhizal networks and chemical signals passed through the air. Yet anthropocentric language forces us to format interspecies relationships and experiences into our own way of thinking. That being said, anthropomorphizing in this way allows us to see our own history, as a species, as still entangled within these large temporal and spatial networks of relationship. We have no choice but to anthropomorphize, we know no other

[33] Margulis, *Symbiotic Planet,* 70
[34] Ibid., 70

way. The forest becomes a model for reciprocity and solidarity, when it seems as if we have lost these ways of connecting within our own species.

Anthropocene

While we have no language for the ecological interconnectedness which not only includes the non-living, but also grants all beings the same agency as humans, Morton coins the antithesis: *the severing.*[35] This term describes the rift between the human and the more-than-human, the divide being nature and culture. Morton describes the separation as happening between the "*reality*" and the "*symbiotic-real".*[36] The "symbiotic-real" is the network of symbiosis across species, as understood by the Rara'muri principles of *Iwi'gara.* The "reality," on the other hand, is the illusion of human exceptionalism, or the idea that we are fundamentally different. The severing is a historic event, because at some point, we forgot our amphibious past, and ignored the symbiogenesis that allowed life to begin branching out from singular cells in the first place. It is not only a historical juncture, however, but also a continuous reinforcement of this ontological struggle.

The severing is contradictory, because human and nature systems are, and forever will be, connected, yet somehow we have fallen for the idea that we are independent. The severing invites dominance over the nonhuman, which in turn perpetuates both in*ter*species and in*tra*species violence. Haraway touches on the idea of the severing, through the description of the disembodiment that occurs under the illusion of the god-trick, justifying the dominance that science often exerts over nature. The severing is what allows the non-living to be considered resources, rather than kin, perpetuating exploitation and extraction. In Haraway's work, she

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[35] This is why I often cite Morton, who has developed terms that help us grapple with our (as humans) positionality within ecology.
[36] Morton, *Dark Ecology.*

portrays the role that science has played in the acceleration of the Anthropocene and climate change, recognizing that it has been used as a capitalist and colonial weapon. It should be noted that the severing is not a universal term, as Indigenous languages maintain the notion of interconnectivity. And in chapter 3, I will recount the Anishinaabe story which teaches, through the sap, the ongoing need for reciprocity between humans and the trees. Within my own work, the severing is made visible in the wound left behind from the process of coring the tree. Beside those left behind by the increment borer, the maple tree bears scars from tapping the trunks to harvest sap, as the dominance over nature is visible through both agricultural and scientific interactions with the symbiotic real.

Reckoning with the severing in the Anthropocene is important, because it situates humans within ecological systems, even under the illusion of separation. The Anthropocene, our current era, is the point in time where human systems are affecting the planet at geologic amplitude. Geologic, as in the processes of fossil fuel extraction and other forms of mining; tectonic uplifts of garbage; mass soil erosion; altering the future landscape and atmosphere on a temporal level beyond our own existence as a species. While the term Anthropocene indicates humans the driving force, Donna Haraway proposes the alternative – "Plantaciocene" –, which specifically identifies capitalistic and colonial systems as responsible for enacting these geologic changes. This distinction is important, because naming a universal human disguises and distracts from the politics, both historic and current, and their role as a threat to both culture and nature.[37] In the words of Robyn Maynard and Leanne Simpson, "it is necessary to move beyond 'human related activities': the climate crisis is tethered to its origins in slavery and colonialism, genocide

[37] Donna Haraway and Anna Tsing, interview by Greg Mttman, "*Reflections on the Plantationocene: A Conversation with Donna Haraway and Anna Tsing,"* Edge Effects, June 18, 2019.

and capitalism."[38] One of the ways in which the plantation is intimately linked to the acceleration of the climate crisis is through the simplification of systems, a process which has a detrimental effect to both human and non-human species. This process of simplification manifests in the ecologically degrading farming practices that destroy topsoil at rates faster than it can rebuild itself. Forest management which degrades ecological resilience is another poignant example of the destructive results of simplification. This ecological simplification, creating monoculture – the apple orchards beyond the stand of maple trees at Montgomery Place – and is necessary for forced or coerced labor inherent to the plantation. Montgomery Place holds the memories of enslavement, the iteration of the plantation-system at its most extreme, a reminder that degradation of the environment is linked with destruction of our own communities.

Consequences entangled with the plantation system include the continuous loss of home, as well as the disruption of generation time. A visceral example of these consequences occurs through deforestation, as the trunks are cut from their roots and the land which supports them, while simultaneous habitat loss ripples outward. The loss of home is cyclic, and humans are included within it, as seen in destruction from flooding or erosion. Erosion includes the loss of topsoil, which consequently impacts food production, as food is also closely tied to a sense of home. Reinforcing climate feedback loops accentuate changes brought about by anthropogenic systems, furthering the sense of a loss of home. The emphasis of "home" should be noted, rather than housing or habitat for any species, because this use of the word implies deeper ties to the land, and also accounts for the land displacement entwined with the plantation system. The disruption of generation time can be conceptualized in a similar fashion, as occurring both on

[38] Robyn Maynard and Leanne Betasamosake Simpson, *Rehearsals for Living.* Haymarket Books, 2022.

ecological and cultural levels, while simultaneously spiraling out of human control, accelerated by global feedback loops. The anthropogenic impacts on changes to the forest can be thought of as the imposition of human timescales on sylvan temporality, as carbon emissions drive the growing misalignment between climate cues and tree phenological cycles, causing increased vulnerability and negatively impacting growth. Additionally, deforestation removes the possibility for decomposition, breaking the cycle of nutrients and energy, and increased carbon dioxide causes temperature change at a rate faster than tree life cycles. Considering the specific human forces at play in accelerating climate change reveals the lack of solidarity between humankind as well as on an ecosystemic level.

Grappling with The Mesh

Working from the principles of kincentric ecology and the Gaia theory, we are able to reimagine our collective symbiotic history, grapple with humankind's connection to climate change, and consider our own relationships to local ecologies. These aforementioned frameworks unearth the ongoing need for reciprocity between the human and the symbiotic real. Additionally, these ways of thinking return agency to the non-human, allowing me to consider the trees as historical actors. The trees can help us understand past climates, yet they also teach us more of the vastness of hyperobjects and the requirement of reciprocity. I return to Carolyn Merchant's three questions, then begin to dig deeper, already freed from the need for an answer, as their answers will always be illegible or inaudible. How do trees make sense of climate change? How do they reckon with the challenge of evolving on an impossible timeline? What does reciprocity between humans and trees look like? What does it sound like? How can we begin to understand (knowing that we will never achieve full understanding) maple tree memory?

With the idea of illegibility in the answers, there is the reminder that we have no language or concepts to grasp the trees' essence, their *liveliness*. Describing multispecies interconnectivity over vast space and time – Morton refers to this as *the mesh* – is twisting and sprawling in nature, difficult to organize into paragraph format. This is where art helps fill this void, with its ability to capture the non-linearity of the mesh and steering into its illegibility. Art is able to show the vastness of the relationships between humans, the land, and the trees, by presenting both instantaneous and deep timescales alongside one another. And it is able to depict symbiotic as ongoing, a constant *weaving*. And other verbs such as *growing, decaying, chewing, fermenting, photosynthesizing, digesting, releasing, dancing.* Through visualizing and sonifying concepts of the mesh, art invites a necessary element of play. Both Haraway and Morton's ontological frameworks state that *play* is a necessary reaction to ecological awareness.

In addition to capturing what language lacks, art is able to grapple the myriad of emotions evoked by gaining ecological awareness. Morton describes the feeling of gaining awareness to the mesh as enchantment. It is the mystery and awe that accompanies the largeness. Yet at the same time, this awareness evokes a sense of weirdness. The reaction to the fact, for instance, that I will never be able to fully discern or understand the far reaching impacts of climate change, or the ways in which trees communicate. Both enchanting, and weird. In the words of Alan Macpherson,

> "This manifests in the uncanniness we experience through the weather, the deep longevity of plastics, and the dizzying sense of spatial and temporal scales that induced, in our growing awareness of the Anthropocene, by even the most mundane of things."[39]

Another reason that awareness of the mesh evokes a sense of weirdness is that it is a reminder of severing. It forces us to step back, and reconsider the contradicting binaries of nature and culture; human and non-human; and living and nonliving.

All of this ecological theory lays the groundwork for my own engagement with the maple trees at Montgomery place. The rings tell the histories of the land these trees take root in and the local atmosphere. Under the microscope, the rings reveal their vessels, which run from the roots, up the trunk, and into the farthest reaching leaves. These vessels made visible are reminders of another way in which humans and these trees are enmeshed; sweet maple sap. The slivers of the rings echo the writing of Morton, humbling me in my inability to ever fully know the histories that the concentric rings tell, about their growth, about the climate, about the land. Then, they invite me to put my ear to the ground, and listen.

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[39] Macpherson, "Art, Trees, and the Enchantment of the Anthropocene," 247

Trunk

Field Data Collection

I come to the forest, this stand of maples alongside the road of Montgomery Place, in search of answers for how these trees have grown over the past century, and how the changing climate may be etched into their trunks in rings. It smells like earth and freshly fallen leaves. Each of the sugar maples I plan to core is decorated with pink or yellow field tape, fluttering in the wind. A few days prior, as I fastened the ribbons to the maple trunks, I spotted these grayish-brown, almost purple, *tiny* mushrooms. Almost unobservable, reaching out towards the sky. They were the size of ticks, and clung to the bark of the maple tree with invisible filaments. It had rained the day before, and tiny streams of water still ran down through the rifts in the bark, past brilliant blue and green tapestries of lichen and moss. The sky is still dotted with reds and golds, but the next Thursday's wind will take the rest of the leaves from the branches, and with them the last memories of the growing season.

Today, when I step over the arches of thorny brambles that separate the trees from the road, the color has drained from the forest. I produce my increment borer, vivid cobalt, which rests heavy and cold in my palm. It is a Haglof 16 " 5.15 mm core diameter 2 threaded Increment Borer. I unscrew the borer, which creates a resounding metallic sound as the spoon and barrel slide from the inside of the handle. Once the borer is reassembled and the spoon is placed out of danger of being stepped on, I pause, palm pressed against the bark, chin lifted up, parallel with the xylem and phloem, to gaze at the crown. I never quite know how to ask: *Is it ok if I take a small chunk of your trunk?* And I never know how to take the stoic silence of the crowns' wiggle in the gentle breeze as a response. While taking tree cores does not kill the tree, the way that felling it to see the complete cross section would, this break in the bark can expose the wood to fungi or disease.

I press the threaded bit of the borer into a rift in the bark, where it will be the most stabilized. In order to catch the threads of the borer within the hardwood, I push my whole body weight into the handle of the borer, all the while holding it steady, my shoes digging into the leaf litter and dirt of the forest floor. Each core is taken at breast height, the tree survey measurement standard, which is also where I have the best traction. I do my best to angle the borer towards the pith, the center of the tree. When the threads finally catch, I pull my weight off of the handle and twist in simple 180 degree rotations, so as to not add torque or stress to the barrel. I imagine it feels like a pinch in the body of the tree. The trunk creaks and groans with each twist, almost like copper hounds, eyes rolled back, tongues outstretched, yawning, again and again and again. Like the insides of my knees, occasionally. An acouchrement of farts.[40] It sounds almost like a door closing, but it doesn't; the tree's groan refuses ambivalence, anticipating detachment. The cold rhythmic creaking of cold metal threads breaking the bark is a reminder of the separation between the human and the non-human, a reminder of the inherent dominance of science over nature. After a few cores, I feel it in my forearms. Coring is an endurance game, according to Neil Pederson, the dendrochronologist who taught me how to core as well as helped guide my

[40] A mispronunciation of a real word, per my friend Lu.

initial research questions. He posits that "soccer players are better at coring than football players."

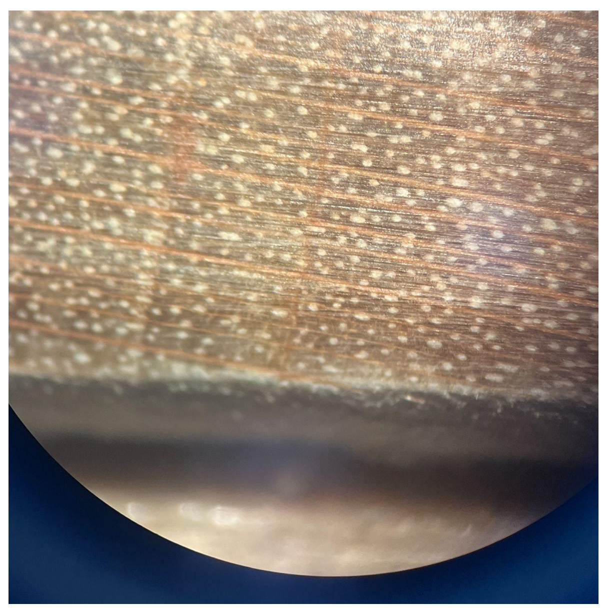
When the barrel reaches what I think is around the center, using the spoon as a guide, I stop twisting to extract the core. I slide the spoon, concave side faced down, between the core and the interior of the barrel. The spoon accentuates my own hand's slight tremor, and wiggles from the pressure of myself and the tree. Once inserted, one twist 180º in the opposite direction and the core snaps free from the rest of the trunk. I slide the spoon out, revealing bark, then cambium, heartwood, a century of fragmented memories, and soft fibrous heartwood rot. The maple core is warm, and smells exactly like you'd expect it to. Holding this core evokes a strong sense of gratitude and reverence for this maple. I slip the thin core into a paper straw to protect it, sealing the ends with masking tape and mark the straw with the date and tree ID number. In steady half turns, this time in reverse, I remove the increment borer with the same pulsating creaks that break the forest silence.

In addition to taking cores, I take diameter at breast height (DBH) measurements of the maple trees. This is done with a DBH field tape, either by hooking the end to a notch in the bark, with the help from a friend, or single handedly in a bear hug embrace. These measurements become a forest of red dots, populating an ArcGIS Field Maps App. Each dot contains the tree ID #, the DBH measurement (cm), and the occasional photo or audio recording of the tree. Before I leave, I thank the tree.

Collecting core samples in November and December, with Leila, Elsa, Annie, and Moselle (some of my friends who helped with sampling) Photo credit during the snowy coring day: Nour Annan.

Crossdating

Back in the lab, I secure each of the cores to a mounting strip, using wood glue and masking tape. When mounting the cores, it is necessary to rotate the cores so that they sit within the divot of the mount the same way they are oriented in the trunk of the tree, vessels running vertically.[41] When the glue is dried, I sand the cores down to 2000 grit, so that under microscope, each of the resin vessels that dot the reddish wood are visible in the freshly polished wood. In the wood, golden red streaks radiate outward from the pith, intersecting with the more prominent annual growth rings. These thin darker lines mark the memory of each years' growth, which I will cross date and measure. The bark, a layer of protection, twisted and fragmented around the pale cambium, the life-giving layer of the tree. Towards the center, the heartwood darkens reddish brown compared to the pale outer rings of the sapwood.



Counting backwards in time, tediously, holding a mechanical pencil, monstrous and unwieldy under the magnification, I dot the rings at each decade. One dot for a decade, two for a half century, three for a century, and four for a millennium. When each core is dated, I notate marker rings, patterns of visually larger or smaller rings within the core, on an excel spreadsheet. This process, called crossdating, slowly constructs the collective forest clock, and is important to ensure that each of the trees

[41] J. Dyer, "Mounting Tree Cores." Department of Geography, Ohio University. Accessed April 30, 2023

align in time. Crossdating two cores from the same trees provide insights on the intricacies and complications within the tree, revealing missing or false rings.

My eye to the microscope, listening for syncopation in the steady beat of growth in the marker rings. These markers echo from tree to tree, hinting at a common signal throughout the forest. I am lucky to be able to cross reference with tree data from Neil Pederson, who took cores of tulip poplars (*Liriodendron tulipifera*), red oak (*Quercus rubra*), and chestnut oak (*Quercus prinus*) in the south woods of Montgomery Place in 2002. While each species reacts to temperature and climate cues differently, significant drought years will be visible for forests in the same region. After studying each of the cores, familiar growth patterns begin to emerge. 2012. 1995. 1988. 1965. 1937.

At the Tree Ring Lab at the Doherty-Lamont Earth Observatory, I hunch over another microscope, staring once again at the intricate sliver of the trunk's growth. With the help of Cari Leland, I measure the distance between each year of growth using a Velmex measuring system, aligning the crosshairs of the microscope with the start and ending points of each ring, clicking to record these distances.

Once the ring widths are measured, they can be analyzed using COFECHA and R, using statistics to determine the stand’s intercorrelation test the relationship between tree growth and local historic climate trends. Intercorrelation between the trees is expected, as the forest experiences the same climate signals. There is much to learn about the specifics of the forests’ mycorrhizal populations, however their presumed presence assists in nutrient and water transfer between the roots. However, a slightly lower intercorrelation coefficient is expected for this specific set of cores, due to low sample size. Additionally, the forest canopy is open, with ample sunlight availability, signifying optimal growing conditions, so that climate signals and other ecological events are not experienced to such an extreme degree. Consequently, some correlation between tree ring widths and climate measurements is expected, based on results from Bishop et al (2015) and Oswald et al (2018), while all the while keeping in mind the effect of low sample size and forest conditions.

Many of the oldest trees were rotten in the heartwood, causing blurry boundaries at the oldest rings. In the field, cores were extracted the moment the trunk resistance decreased, so as to not lose traction in the threads and get the borer stuck. Because of this, many of the cores do not reach the pith, so the actual ages of many of the trees still remains a mystery; the oldest tree dates back to 1895, yet many of the largest trees most likely date back to the early 1800's.

Creating a Chronology

Out of all of the cross dated cores, I only measured the cores whose crossdating I was most confident in, and then tested these resulting values using the program COFECHA. COFECHA is a computer program which tests crossdating accuracy and calculates statistics for tree ring series correlation. The results from the COFECHA output, using the default parameters, found that the mean intercorrelation for the cores was 0.515, meaning that there is a moderate relationship between each of the individual tree cores, as expected. COFECHA software also tests correlations in fifty year segments, with twenty-five year overlap periods, in order to ensure proper dating during crossdating and measurement. In the case of two of the cores, whose bark had separated from the outer rings out in the field, COFECHA predicted the best possible shift, based on the overlapping correlations, and Cari Leland made these changes for me in XDate. In R, I was able to use the raw ring widths to calculate the stands' mean sensitivity, which is the variability in growth from year to year, where 1 = every tree ring is different and 0 = no ring is different. The Montgomery Place Maples had a mean sensitivity of 0.249, meaning that there is some degree of consistent growth.

After the raw ring widths were read into R, using the treeclim and dplR packages, the data was detrended, removing ecological and age related effects on tree growth.[42] This process standardizes all of the trees, and allows for visualizing and identifying cyclic patterns, such as climate signals and their impact on the forest (Figure 1).The detrended tree ring widths were then used to create a ring width index (RWI), which shows whether a given years' growth was above or below the average growth for the tree. The sample trees were all detrended using a cubic smoothing spline. In the COFECHA output, the master dating series also shows standardized residual time series, with dashes illustrating the mean relative growth for each year. This visualization shows a cyclic pattern (Figure 2), like a decadal sine wave of forest growth.

The detrended data revealed patterns also visible in the COFECHA output, which later I embroidered onto a quilt, as an unconventional Figure 2. The resulting RWI series had a calculated expressed population signal (EPS) of 0.796, which is a measure of whether there is a common signal between the trees. EPS is the measure of how well the ring width series fits a "true" chronology, which in turn makes RWI suitable for climate reconstruction.While the standard in dendrochronology is an EPS threshold of >0.85, which means my ring width is not strongly correlated. However this is an arbitrary number, and increased variability is expected with such a low sample size.

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[42] Zang C, Biondi F (2015). "treeclim: an R package for the numerical calibration of proxy-climate relationships." *Ecography*, 38(4), 431-436. ISSN 1600-0587, doi:10.1111/ecog.01335.;
Bunn A, Korpela M, Biondi F, Campelo F, Mérian P, Qeadan F, Zang C (2022). *dplR: Dendrochronology Program Library in R*. R package version 1.7.4, https://CRAN.R-project.org/package=dplR.

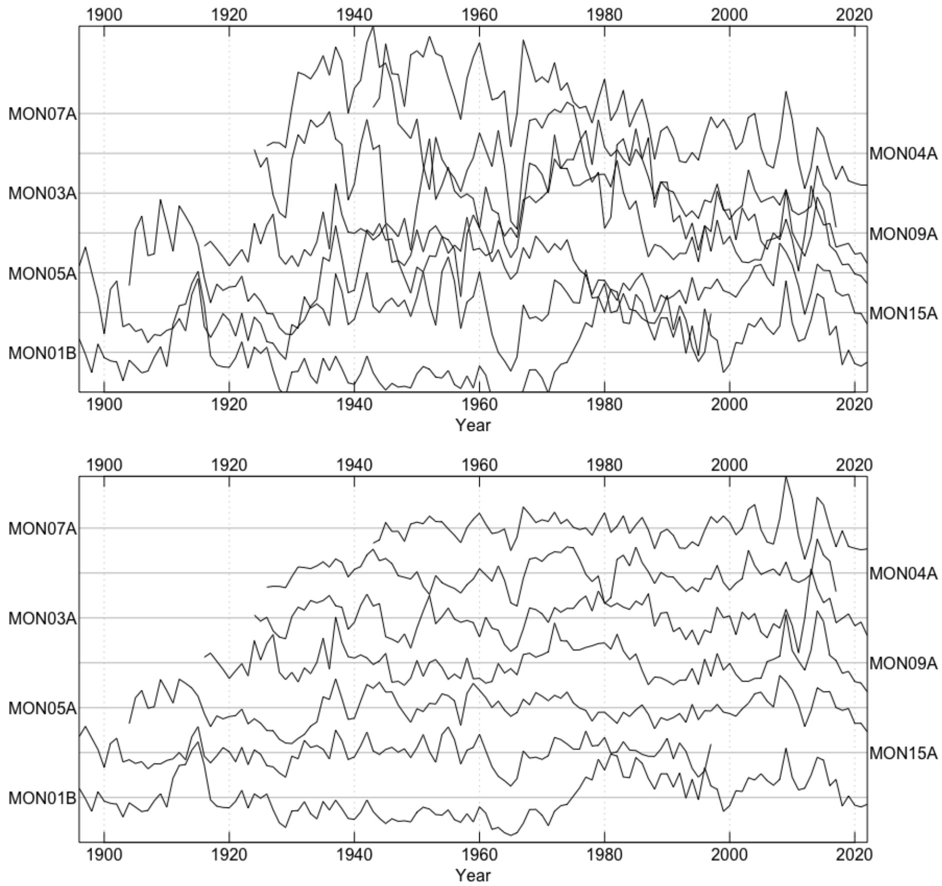

Figure 1. Spaghetti plots of the seven tree cores (MON01B to MON15A) visualizing tree growth over time at Montgomery Place, both before (above) and after (below) detrending data. Potential climate related patterns become more visible in the latter plot.

The forest as a whole reacts to climatic signals, albeit moderately, in decadal exhalations. The rhythm between maple trees and climate signals is expressed through a standard chronology (Figure 3), using the RWI, a reminder of the forest as a whole. Standard chronology leaves low frequency variability, rather than removing auto-correlation, or the persistence of the effect of the previous year's growth on the next.[43]

[43] Stockton Maxwell, "Creating a tree-ring chronology in dplR." YouTube Video, Oct 19, 2021, https://www.youtube.com/watch?v=PQaqq1bm82A

Figure 2. COFECHA output of relative growth of the sugar maples at Montgomery Place, embroidered on a quilt.

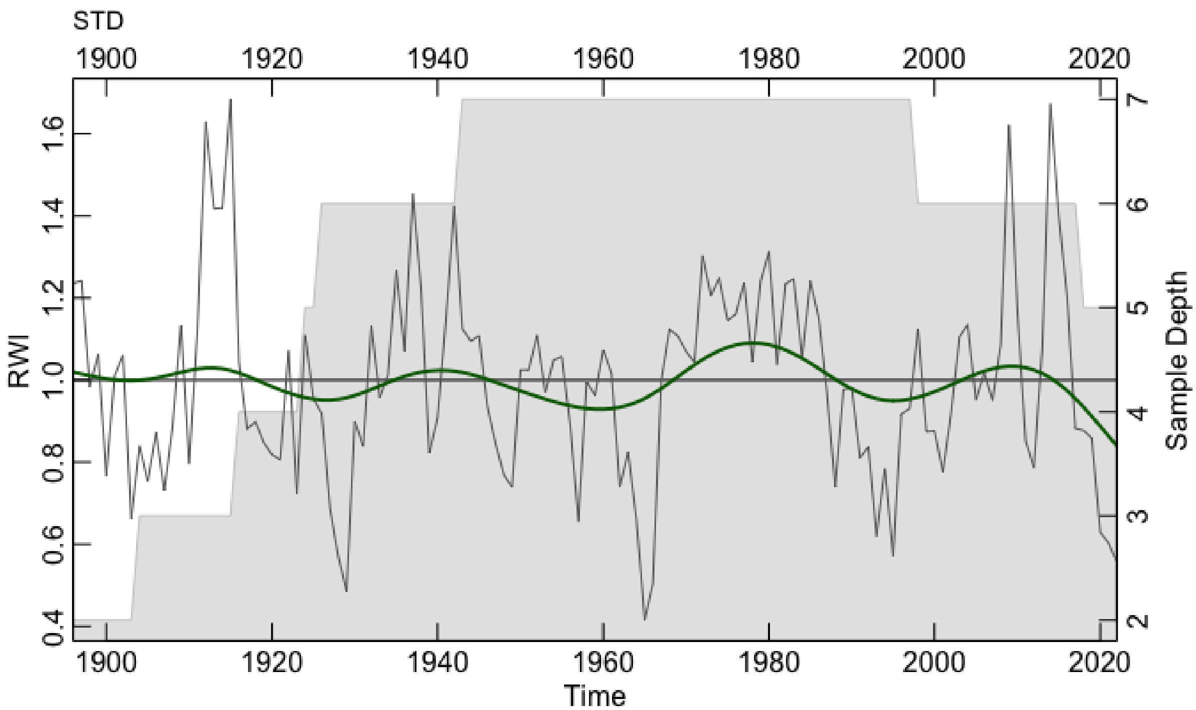

Figure 3. Standard Chronology of Trees at Montgomery Place, showing the time series of the maple ring ring width index (RWI) as the jagged gray line. RWI is then fit to a cubic smoothing spline, shown in the thicker green line, which removes trends from the data. Sample depth is illustrated as the gray histogram.

Both depictions of data (Figure 2; 3) capture the natural rhythm of the forest over time, and given the miniscule sample size, it is expected that the forest as a whole would amplify this. However, it should be noted that not all of the cores collected were measured and cross dated, due to blurry ring boundaries which obscured visual crossdating, implying missing memory. The cores which were difficult to visually crossdate were not measured, because of this uncertainty. The sample of ring width indices are biased, although they can still serve as some representation of the forest.

It should also be noted that my assessment on these trees' growth was focused on the rings, ignoring the condition of the canopy almost entirely. The most straightforward reason for this was that I conducted sampling during the fall and winter, when I had no idea which branches were defoliated or not. And so I have a pinhole glimpse into the history of these maple trees, which nonetheless allows me to draw connections between their growth and past climate conditions.

With help from Neil Pederson's Montgomery Place Data data on the tulip poplars, white oaks, and chestnut oaks, I was able to compare notable growth years between all species. These four different species had moments throughout time when their rhythms overlapped; in 1965, for instance, all four species were in sync and showed very little growth.[44] Thus, within their rings, these trees hold memories of one of New England's worst droughts in history, which is shown in the chronology with a steep dip in growth right after 1960, when the drought began (Figure 3). This drought affected most of the northeastern states, drying most municipal water supplies, devastating most croplands.[45] I imagine the Sawkill at this time, water barely trickling over the crest of the waterfall, as the forest ached with thirst. Poplars, Oaks, and Maple alike, all hold the memory of these years of cracked clay.

These moments of forest synchronicity across species provide clarity, yet other instances of asynchronicity spur mystery, when only one species doesn't echo the same marker rings. In this case, I am referring to what I call the 1981 Spongy Moth Maple Mystery. Each species has different rhythms of notable marker rings, overlapping with other species during some years, and having their own independent years of lower growth in others. Neil's tree data, which have a much stronger sample depth, only have two instances of alignment between all three species: 1965 and 1981, meaning that during these periods, something significant had occurred in the forest. Both Neil and Cari told me during the cross-dating process that I would probably see

[44] Neil Pederson, 2002, "MontQUMO COFECHA Output," "MontQURU COFECHA Output," "MontLITU COFECHA Output" Accessed 4 Apr 2023
[45] "The 1965 Drought, New England's Worst Ever," *New England Historical Society*, accessed April 4, 2023, https://newenglandhistoricalsociety.com/1965-drought-new-englands-worst-ever/.

marker rings in 1981, the year that spongy moths (*Lymantria dispar*) overtook forests in the northeast, and most severely the Hudson Valley.[46] It was printed on the front page of the New York Times that year: "GYPSY MOTH CAUSED RECORD LOSSES IN '81 IN NORTHEASTERN U.S.," and inscribed in the growth rings of Neil's trees, marking the devastating defoliation at the jaws of the insects.[47] All of this information – with the additional fact that their favorite food is hardwood trees – left me perplexed when this history was not visible in my own maples during crossdating as well as measuring. What had happened to these maples, to make them not experience decreased growth, when these other trees had suffered so much foliar damage??

After months of confusion on the Spongy Moth Mystery, Beate and I reached some level of clarity, after considering the surrounding area. Beyond the stand of trees that I sampled are the Montgomery Place Orchards, in parallel rows of apples and pears. We speculated that perhaps the neighboring orchards might have sprayed DDT on their trees, in the wake of the spongy moths, which would have impacted the presence of these defoliating pests on the maples. Neil's trees, on the other hand, are in the south woods, further from the orchards and additionally protected by a deed. This may describe the discrepancy in tree growth that year. While none of this information is confirmed, it is the most compelling explanation.

Past Climate Comparisons

Building the connection between past climate and the growth rings though correlation function analysis is a way of reconstructing the tree's memory in terms that we are able to

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[46] Harold Faber, "GYPSY MOTH CAUSED RECORD LOSSES IN '81 IN NORTHEASTERN U.S.," *New York Times,* Aug 10 1981, https://www.nytimes.com/1981/08/10/nyregion/gypsy-moth-caused-record-losses-in-81-in-northeastern-us.html

[47] These moths have since been re-named Spongy Moths.

interpret. This is done in the program R with the function dcc, in the treeclim package, which compares climate data to the chronology. I sourced climate data from PRISM, which included monthly minimum temperature (ºF) and precipitation (inches) for Dutchess County, NY, between the years 1985 and 2022.[48]

For the climate comparison with the tree rings, my time scale shifted to measurements only between 1920 and 2022, as ring width sample depth became too small to be usable in the early 1900's and beyond. In the correlation response analysis, the time frame for the maples' response to minimum temperatures (Tmin) and precipitation (Precip) were set to range from the previous June until the current September of a given year (Figures 4 and 5). This is because climate conditions of the previous growing season impact the subsequent year (Figure 6).

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[48] PRISM Climate Group, Oregon State University, https://prism.oregonstate.edu, data created 12 Mar 2023, accessed 4 Apr 2023.

Figure 4. Response correlation between minimum temperature and tree ring indices. May shows a significant correlation coefficient on growth. Past growing season months are shown in lowercase labels, and current growing season months in capitals.

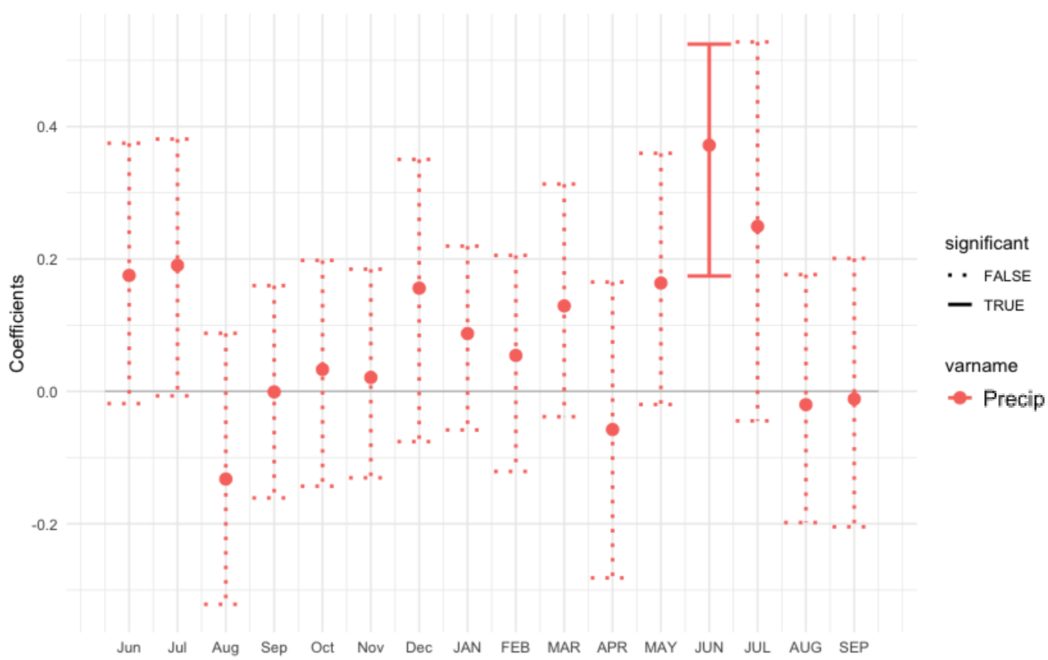


Figure 5. Response correlation between monthly mean precipitation and tree ring indices. June shows a significant correlation coefficient on growth.

Low correlation between both Tmin and precipitation are expected, again due to low sample size. However the late spring/early summer months did appear to have statistically significant correlation coefficients for both climate variables. These significant correlation coefficients are depicted in solid red lines in figures 4 and 5. Minimum temperature for the current year May had a correlation coefficient of 0.174, and precipitation for the current year June had a correlation coefficient of 0.372. These significant values were slightly to my surprise, as I, for one, had low expectations for any sort of correlation in regards to the sample depth. I also expected different months to have significant correlation between climate variables and tree growth, given the study by Oswald et al (2018), which isolated April, and September to be important phenological periods for maple tree growth.

The memory stored in the tree rings can be translated through correlation response analysis, by adjusting the time frame to include the current given growing year, the previous year, *and* the year before that (Figure 6).

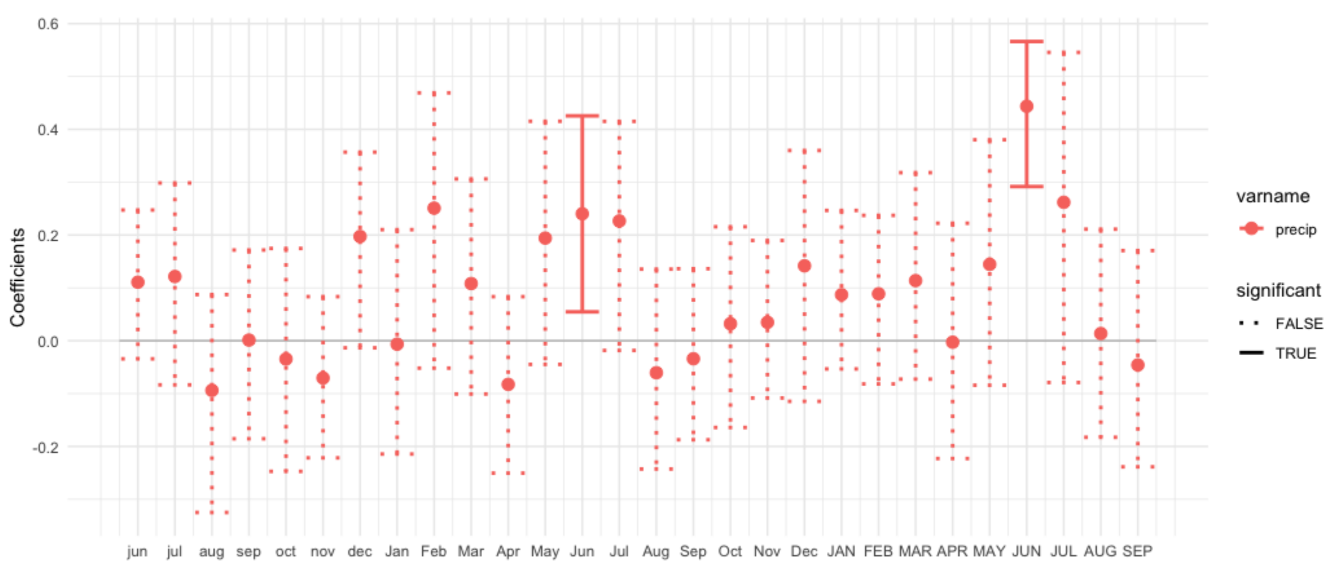


Figure 6. A visualization of tree memory through growth response to precipitation. The previous year's precipitation for June impacts growth, but this annual ripple effect does not continue further back in time.

Sugar maple memory is stored in the rings, which can be interpreted and visualized through dendrochronology, allowing historical forest-climate connections to be made. Unfortunately, I was unable to depict and interpret these connections over time, visualizing the impact of climate change on sugar maple growth over the past decades. Further studies, and increasing sample depth, could also deepen our understanding of sugar maple memory of past climate change. Additionally, modeling future emission scenarios with the foundation of historic tree growth could allow us to make guesses about future maple tree health. While the sugar maple memory is collective, it is isolated to that one species, meaning that a continued comparison with other local species' chronologies would be beneficial in future studies.

The Severing in Action

Doing dendrochronology reveals forest memory, drawing connections between climate and maple growth, and yet it falls short, all the while reinforcing the pitfalls of anthropocentrism as well as Morton's idea of the severing. There is something beautiful about the imperceptible nature of the entire process. (That being the process of trying to understand forest memory.) The idea of uncertainty, to some degree of which is inherent in the scientific method, brings up once again the humbling of science. I found myself, during this whole process, behind a claw machine game called science. The contents are insects, wind, lichens, pebbles, oil that swirls pink and orange atop a mud puddle, fungus with a Latin name I can't remember, and a huge decaying tree in the middle. The tree will rot, disappear, and reappear as raspberry brambles and silver birch saplings before I, or anyone, figures out how to drop the crane and scratch the surface of the softening bark.

This is the severing in action, the separation of the reality and the symbiotic real. Embedded within the latter, the symbiotic real, is the truth that we are included within forest relationships. Shifting our ontological perspective, in a way that grants agency to other species as historical actors, allows us to grapple with the driving forces of ecological decline, recognizing our own entanglements as humans. Describing Maple's memory in full requires addressing the traps of the dichotomies of the human/nonhuman and living/nonliving, rifts which are upheld by Western scientific ontology and reinforced by anthropocentric language. These separations cause the disembodiment between ourselves and what we are studying, as presented by Haraways' work in the previous chapter. This statement on language does not include traditional ecological knowledge (TEK), such as the concept of *Iwı´gara,* which does invite the non-human and non-living into equal forms of being.

I often end up tying myself in knots attempting to detangle from Western scientific ontology, yet I attempt to incorporate these small rephrases into my own practice. Rephrasing, of course, from language which views the tree as an object rather than a being, the way in which dendrochronology seldom refers to them as "teachers." Anthropocentric language and epistemology will do this, when we don't understand a way of being, avoiding the ever-feared anthropomorphism. While this is taboo in the scientific community, Suzanne Simard, the scientist who first discovered that forests were connected through mycorrhizal networks, reflects on anthropomorphism, and in an interview, states:

> "It's a way of saying, "Yeah, we're superior, we're objective, we're different. We can overlook—we can oversee this stuff in an objective way. We can't put ourselves in this,

> because we're separate, we're different." Well, you know what? That is the absolute crux of our problem."[49]

Describing non-human ways of being is the act of teetering atop a balance beam, between anthropomorphism and respecting these differences while lacking the language to do so. Where Western science struggles to address this ontological can of worms, I see no choice but to further explore iterations of the deeper meaning of forest memory, through my own relationship with the woods. This takes the form of making art, which compliments scientific communication, yet also speaks for itself. It takes the form of listening. And it takes the form (if you're lucky enough to taste it) of syrup, atop a big stack of pancakes.

[49] Suzanne Simard, "Finding the Mother Tree: An Interview with Suzanne Simard," by Emmanuel Vaughan-Lee, *Emergence Magazine,* October 26, 2022. https://emergencemagazine.org/interview/finding-the-mother-tree/.

Sap

"This is spring music as surely as the cardinals insistent whistle"

– Robin Wall Kimmerer, *Braiding Sweetgrass*

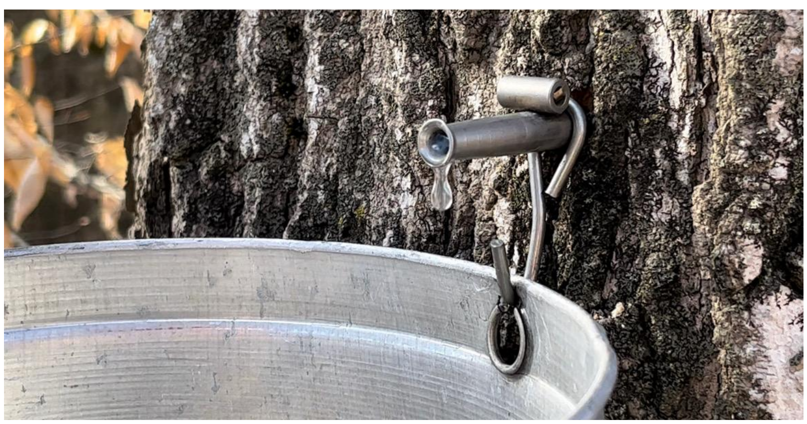
In February, the land begins to thaw, and buds, sensing the coming spring, send signals down to the roots for food. As trees send their sugars up from underground, There is a pulse of life that can be heard in the sound of the sap's muted plink into buckets. The rhythm is patient, persistent, and the whole forest seems to hold its breath. Part of the sound is the hollow thud against the galvanized steel. The other half of the sound is the silence between each drop, as sap wells on the tip of the spile and water tension between each of the sap molecules builds until the droplet begins to tremor, and – ting!

The sap plinks into the metal buckets, changing pitch throughout the day. Robin Wall Kimmerer, an Indigenous scientist, writer, and teacher of TEK, describes this sound in her book, *Braiding Sweetgrass,* as the song of reciprocity between the humans, the trees, and the seasons. Sap connects us to the land through time, the silent scars on the bark link us to others who have tasted the sap years before us. And as sap boils down, sweetening slightly with every spoonful, it condenses into a story of forest memory Around the fire, we tell jokes and stories, weaving history and ecology into the syrup.

The story of sap is rooted in the reciprocity between humans and maple trees, and tells of the patience required in this relationship. In *Braiding Sweetgrass,* Robin Wall Kimmerer recounts the Anishinaabe story of Nanabozho, the Teacher and Original Man, who one day found the people had become lazy and greedy and were lying beneath the maple trees, drinking the sweet, thick syrup straight from the vessels. Their neglected village showed the people's laziness in the unmended fishing nets, untended gardens, and tools in disarray:

> "They did not do their ceremonies or care for one another. He knew his responsibility so he went to the river and dipped up many buckets of water. He poured the water straight into the maple trees to dilute the syrup. Today, maple sap flows like a stream of water with only a trace of sweetness to remind the people both of possibility and of responsibility. And so it is that it takes forty gallons of sap to make a gallon of syrup."[50]

Nanabozho teaches that the work should never be too easy; "the responsibility does not lie with the maples alone. The other half belongs to us; we participate in its transformation. It is our work, and our gratitude, that distills the sweetness."[51]



As spring breaks, photosensors in the buds sense the returning daylight, keeping time with the sun as we inch towards the equinox, anticipating new growth. These buds are composed of phytochromes, light absorbing pigments that act as temperature sensors, and contain the information to become leaves and branches; instructions for a waxing source of shade as they

[50] Robin Wall Kimmerer, *Braiding Sweetgrass,* (Milkweed Editions, 2013), 63
[51] Kimmerer, *Braiding Sweetgrass,* 69

unfurl.[52] When the time is right, the tree sends a hormonal signal down to the roots for food. The hormone produces amylase within the tree, an enzyme that breaks down starches stored in the roots to create smaller sugar molecules, which are then pumped up towards the crown.[53] The sap flows through a combination of capillary action and osmosis, rushing up through the xylem. Peter Wohlleben writes, in *The Hidden Life of Trees,* that "water shoots up the trunk with such force that if you place a stethoscope against the tree, you can actually hear it."[54] This is the only time of year when sucrose-rich sap flows up towards the branches; once the leaves develop and begin to photosynthesize, producing their own sugars, this is sent back to the roots through the phloem vessels in the tree. While the barren tree still appears dormant, the muscular force of sap flow creates a pressure on the inner walls up to 40 pounds per square inch.[55] Wohlleben writes that listening to the vessels for the sound of sap flow has been utilized to know when the time is right to tap the trees in the northeast.[56] Indigenous wisdom uses the thawed rings around the base of the trunks as a cue of the dawning sap season.[57] As the temperatures rise above freezing during the day, the dark trunk of the tree absorbs the sun's warmth, melting a hollow at the base of the roots, hinting that the sap has begun to flow up through the pale sapwood. *I* know it is almost time to tap when Rebecca texts me to ask me to help stack wood, and is delighted by my reciprocated enthusiasm for the task.

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[52] Kimmerer, *Braiding Sweetgrass, 65.*
[53] Ibid., *68.*
[54] Peter Wohlleben, *The Hidden Life of Trees,* 58
[55] Massachusetts Maple Producers Association, "Explaining Sap Flow," *Massachusetts Maple Producers Association,* accessed April 30, 2023, https://www.massmaple.org/about-maple-syrup/how-sugar-maple-trees-work/#:~:text=A%20rise%20in%20temperature%20of,tree's%20roots%20on%20warm%20days.
[56] Wohlleben, *The Hidden Life of Trees,* 58
[57] Kimmerer, *Braiding Sweetgrass,* 65

We tapped the trees at Montgomery place on February 10th, 2023. We were a crew of Bard Farm volunteers, including Rebecca and myself, and a handful of crows in the crowns of the maples. It was the second day that week that the untethered, unmistakable smell of spring lingered in the warming air. We inspect each trunk, running our fingers over the fresh increment borer scars from the fall's fieldwork, as well as healed tap holes from years prior. Some are still hollow, while other holes, decades older, have grown belly buttons where the bark has begun to seal the wound. Drilling into the sapwood is much faster than the tedious crank of the borer, and as soon as the bit is removed, the hole wells with sap until the water tension breaks and it rushes down the bark in a tiny sweet rivulet. The sound of hammer against spile resonates throughout the forest, along with yelps of joy in reaction to the spiles welling instantly with sap. Our shouts of excitement ring throughout the entire forest, and we become cicadas. Crows call out to one another in a language we do not know, accompanied by the red wing blackbird's occasional raspy *conk-cra-*^{reee}, and we can only guess the coming spring is the talk of their town too.

At night, when the temperature drops below freezing, the vessels are replenished with sap, suctioned up from the roots. Climate is woven into the story of maple sugaring, as the alternating freezing and thawing temperatures in the night and day are critical to sap flow as well as traditional syrup production. Indigenous maple sugaring practices use the freezing nights to distill the sap, collecting the liquid in shallow troughs, where ice would gather at the top, leaving behind the more condensed, sweeter sap, thus reducing the amount of energy required to boil down to create syrup.[58] Kimmerer reminds us of the "elegant connections; maple sap runs at the one time of year when this method is possible."[59] And so I approach every step of the sugaring

[58] Kimmerer, *Braiding Sweetgrass*
[59] Ibid.

process with reverence, graciously pouring the sap into my five gallon bucket. As I collect sap, I scoop out the occasional drowning moth, and watch as ants pace the bark near the spile, sipping on the sugars. While the photoreceptors keep the calendar, the sap connects other species – insects and humans alike – to the collective forest clock.

Trees in a forest have a collective sense of time, along with shared senses of space, and self. Again, the trees' proprioceptive networks emerge. The sugars, food for future growth, also carry the memory of past photosynthesis. It is an interspecies life blood, connecting the threads of bacterial, fungal, human, and tree lives into a historical forest tapestry. The growth rings visualize forest memory, and the collective clock is also shown through the COFECHA's intercorrelation, a quantification of the ebb and flow of collective maple tree growth over long periods of time. This clock is woven through relationships, one poignant example being the recurrence of mast years, and the ecological ripple effect, as other species experience this increase in seed production. The abundance of acorns, pine cones, or maple keys, brought about by a mast year, results in a ripple out across the stomachs of the forest, over the next few years. First, the mast year brings increased populations of birds, mice, and squirrels, then the ripple extends to the hawks and foxes. The memories of the mast years are also stored in the tree rings, as trees typically put on smaller growth rings during these periods.

These forest clocks that connect outward in the biological world tune sort of a collective clock. Patricia Kaishian told me once that cicadas also rely upon cues from thes waiting in the roots of the trees until the right moment to come out of the ground.[60] The most agreed upon explanation for the cicada synchronicity is that they wait for cues from the trees, tasting for the

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[60] Anecdote from Patricia Kaishian, during her Queer Ecology Seminar in the fall of 2022, which is an excerpt from her upcoming book, Forest Euphoria.

right cocktail of sugars in the sap.[61] Throughout the growing season, the sap composition changes, and cicadas can taste the seasonal rhythm of trees growing and shedding leaves. Thus and so the sap connects other species of the forest, including humans, weaving these interactions over time in polyrhythm; Cicadas emerge every seventeen years and we return annually, buckets in hand.

This year's sap season drums into the empty bottoms of sap buckets, a steady reminder of the effect of the climate crisis on maple sugaring. February's erratic temperatures bring 60º days that urge us to grab a frisbee or a pair of binoculars and go outside, enjoying the sun while simultaneously attempting to come to terms with the velocity of global warming. The warm days and above-freezing nights that dot the forecast leave the sap buckets dry. Over the past three years of sugaring at the Bard Farm, we have tapped earlier and earlier into the calendar year. In 2021, we tapped on the 25th of February, in 2022 we tapped on the 23rd, but could have tapped earlier, and this year we tapped on the 10th, and could have tapped earlier.[62] As the Farm has only been sugaring in the past few years at a small scale, maple sap data in relation to the weather is only anecdotal. However, future climate trends will undoubtedly strangle the sugaring season in the Hudson Valley, as maple sugaring production range is expected to migrate to around the 48th parallel by 2100.[63] Maple sugaring season is projected to shorten, and sugar content decrease by 0.1 Brix for every 1ºC of warming[64]. Emptying one of the sap buckets, I spot

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[61] Meg Matthias, "Why Do Some Cicadas Appear Only Every 17 Years?," *Encyclopedia Britannica*, April 13, 2021, https://www.britannica.com/story/why-do-some-cicadas-appear-only-every-17-years.

[62] Rebecca Yoshino, (Bard Farm Manager), *Conversation,* February 21, 2023.

[63] Joshua M., Rapp, David A. Lutz, Ryan D. Huish, Boris Dufour, Selena Ahmed, Toni Lyn Morelli, and Kristina A. Stinson. "Finding the sweet spot: Shifting optimal climate for maple syrup production in North America." Forest Ecology and Management 448 (2019): 187-197. https://www.sciencedirect.com/science/article/pii/S0378112719303019

[64] Ibid.

a wood tick, making its ascent up my pant leg. *You should still be in hibernation!* I crush him under my thumb nail.[65] Later, I find a tiny deer tick crawling up my shin, but he falls from my fingertips, back into the brown underbrush, before I have the chance to squash him. A week later, snow quilts the ravine where I found the ticks, and the thaw from this storm brings a new flush of sap to our buckets. (Sap season, and all of the subsequent shoulder seasons – *mud season, you thought winter is over but it's not season…*– will forever be a tease.)

Across the Hudson River, the parallel pattern of the Catskill mountain sedimentary bedrock is visible through the bare branches, tinted purple in the distance. The layered patterns of the mountain become illuminated during the period of tree senescence, and will soon become invisible again, hidden under bursting foliage. Beneath the bark, as well, the stripped down February landscape is churning with life; we must rely on our ears and noses to sense the sap flow. The ever so slight plinking of sap slowly fills buckets, ringing throughout the forest, a flickering of the unseen processes within the xylem. The ephemerality of sound captures the essence of sap, who's meaning and memory extends physiology to the poetics of the mesh. Sound waves are unseen and transient, for a moment they "[carry] meaning and memory imparted by [their] maker [before disappearing.]"[66] David George Haskell, a biologist and writer, also describes the sound of sap flow, yet he uses technology to sonify the pulse of the trees' life-blood, measuring the diameter of maple twigs throughout the day and converting the results into sound. The measurements become notes played by an electronic piano, with pitch

[65] Throughout this project, I have begun to apply Morton's philosophy on the relationships between the human and the non-human to the maple trees. I am constantly reminded of the severing, especially in the act of drilling into the trunks. When it comes to ticks, all reconciliation of the ontological separation between the human and the non-human goes out the window.
[66] David Haskell, "100 Sounds and a Culture of Listening," *Spirituality Health,* accessed April 30, 2023, https://www.spiritualityhealth.com/100-sounds-culture-listening.

corresponding to the changing size of the twig. The piano plays high notes at midnight, when the twig is most full of water, yet cascades down the keys after sunrise, as water begins flowing and the twigs vessels contract inward.[67] As the days go by, the twig adds new growth, and the piano's scales of the daily water flow pitches upward. The result is a frantic pulse, rising and falling in a steady climb up the keys, in chromatic scale of C, which contradicts the tree's usual semblance of silence and stillness.

Inspired by Wohlleben's writing on the velocity of sap flow, I went out to the woods with a stethoscope slung around my neck, and knelt at the base of a tree whose spile dropped steadily. Placing the chestpiece to the bark, I just sat, and listened. Listening to the trees can be a window into the connective nature of sap. I heard the amplified sounds of the slight movements of my finger joints, a deep creaking as they worked to press the stethoscope to the rough surface. I heard the sounds of the leaves in constant readjustment on the forest floor, gently rustling against the base of the trunk and the base of my own knees. Together these sounds mixed with the silence in my ears, creating subsonic murmurs. While I heard no pulse of sap through the xylem, I was able to hear the sounds of myself listening to the tree. And I imagine that it sounds similar to the noise that sap flow makes.

The sounds of the sap are made up of the interactions between the human and the tree; the drops become amplified by the galvanized steel, placed on the spile by human hands, and the relationship between species resonates with each plink. Sap is a symbol of relationship as well as a reminder of the *symbiotic real*, the result of messy interdependence, through the sounds of insistent plinking, the crackling fire, and the rumbling boil. In the evaporator pan, the sap

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[67] David Haskell, "Maple," *Songs of the Trees,* accessed April 30, 2023, https://dghaskell.com/the-songs-of-trees/the-trees/maple/.

becomes animated, rising up in churning white anthills, slowly thickening, sweetening. The boiling sap's low, resounding hum crescendos as the flames climb, and energy is released from the burning wood in pops and cracks. The energy of the fire amplifies the sounds, the smells, and the idea of sap as the actualization of the human-tree twined. This relationship can be sonified, yet it can also be *smelled* in the steam and woodsmoke billowing off evaporator, and *tasted* in the maple sugars. Trees, of course, communicate through the unheard releases of chemical compounds; thus smelling becomes a form of listening.

The practice of listening to the trees through the stethoscope and tasting sap my tongue, reminds me of Emilio Rojas' performance art piece "Hands to Hold." As a part of a greater collaboration with poet Pamela Sneed, Rojas sat beneath a sugar maple at Montgomery Place, drinking sap from a sumac spile for six and a half hours. The performance is a meditation on breath, and on the similarities between the human lung and the tree's crown, and an exploration of place. Rojas writes;

> "Beings in symbiosis / Invisible rhythms, / we've forgotten how to breathe / into each other's utterances, / language / became a thing of the mouth, / And the vocal cords, / And the body forgot it speech, / when did we think ourselves / different from the land / from each other? / then our mother? / How much blood, / sap, serum, suero, / sweat has fed this soil? / Whose hands, whose sweat, / whose blood has dripped / into this dirt, we try to call home?"[68]

Through the practice of sipping sap, Rojas explores the deeper history rooted in the land of Montgomery Place. Practices of exploring the human relationships with the land reveal the

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[68] Emilio Rojas. *Hands that Hold,* performance and poem, 2021, Center for Human Rights and the Arts, Bard College, https://chra.bard.edu/files/2021/06/Sneed-Rojas-Hands-That-Hold.pdf

history of labor at Montgomery Place, specifically the history of enslavement. "Hands to Hold" is a reminder of the persistence of multispecies memory of the land, and how this exploration of memory is held in the sap sugars, which forces us to reckon with our role as settlers. The same colonial force that removed Munsee-Mohicans from this land is intertwined with the anthropogenic systems that perpetuate climate change, viewing the land and its inhabitants as resources rather than kin. Learning from the Raramuri concept of *Iwı´gara,* which cultivates solidarity between all forms of being, which first demands cultivating kinship within ourselves.[69]

Entwined with *Iwı´gara,* is the Raramuri ongoing history which links them to trees. This origin story echoes many Indigenous cultures; Abenaki origin is rooted in the ash tree, for example.[70] Thus some form of reciprocity is ongoing, required, and celebrated in forms of sustainable stewardship of forests and other agroecological systems. This contrasts the colonial extractive lens, upheld now by neoliberalism, where trees are valued primarily for their lumber and their sap. In response to the climate crisis, trees are additionally valued for their role in facilitating carbon sequestration, for their ability to counteract emissions from human industry through photosynthesis.

The Anishinaabe story of sap is a reminder of the indigenous understandings of forest relationships, including how humans are woven into this ecological fabric. The sounds from the trees are an actualization of these relationships, a flickering of interconnectivity. "I learned very quickly that no tree sings alone," Haskell writes; "Every sound emerges from a chorus of inseparable plants, bacteria, fungi, and animals."[71] Even the sound of wind in the branches is an

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[69] Salmon, Enrique. *Kincentric Ecology.* 1331
[70] Ibid., 1331
[71] David Haskell, "Q & A with the author," *David George Haskell,* Accessed April 30, 2023, https://dghaskell.com/the-songs-of-trees/q-a-with-the-author/

audible exhale, a gesture of the relationship between the air and the trees; energy cycles from the sun, and photosynthesis grounds carbon in the roots, trunk, and soils, letting out a breath of oxygen through the stomata. Over the hormonal and chemical signals passed between the trees, we hear human laughter, insect rasps and clicks, branch brushing branch in the wind, warbling, croaking, and the static of simply being in kin. The sap percussion will carry on playing, for anyone who will listen, until the nights warm and peepers emerge slowly from the muck, singing.

Branches

Green returns to the forest in visceral budburst, and twigs inch outwards, brushing against neighboring trees in the wind. Considering the canopy's ever expanding spatial span, the branches become an embodiment of the trees' presence in space. The branches allow me to ignore deep time for a moment, with the reassurance that all of this memory is held neatly in concentric rings, and focus on the present forest interactions and their connections to the land. The relationship between the climate, humans, and maple trees deeply involves *place,* just as it does time. The present is sprawling, messy, and the faint hint of red in the leaves' first unfurling is a reminder of the leaves ephemerality: photosynthesis, chlorophyll drains, leaves scatter the ground, senescence, sap flow, bud burst, again and again and again. But the next day they are undeniably green, and cast a slightly bigger shadow against the forest floor.

The Gift of Shade

As the leaves soak up the sun, the dappled sunlight left behind creates a map that creeps across the leaves over the course of the day. Are these trees aware of their own shade? And are they aware that their shade is a gift to others? Sitting at the base of a tree, where moss and lichen cling to the bark at the foot of the trunk, the shade is a gift of rest from the sun. (79º, I will add, is far too hot for April.) The shade provided by the canopy informs the composition of the understory, such as shade tolerant shrubs, grasses, vines, and the brambles rooted at the base of trunks, whose thorns would often snag on my pant legs during the coring process.[72] And yet, trees are to some degree aware of their shade in its form of protection, as parent trees deprive their offspring of sunlight, in order to strengthen the cores of saplings' trunks.[73] This idea of forest upbringing reminds me of Margulis' writing on the networks of proprioception, leading me to believe that to have a sense of self is to have a sense of place.

Mapping is a powerful spatial story teller, which also helps narrate my relationship with the study area. My study area was visualized through the ArcGIS Field Maps app, where each red dot represented a tree. However, I am still in search of ways to more accurately depict the other aspects of this project through maps (some of this is done through the installation and sound recordings, which I will describe in the subsequent chapter.) When Beate asked me how I actually came to choose this specific study area, I didn't have an answer, because this patch seemed to be the obvious choice; this project demanded some degree of locality for the basis of a relationship. "But how did you know which specific tree to core?" I didn't have an answer for that one either, because it was a combination slowly working eastward from the beginning of the stand, and wandering about until I found one that just felt right. For all I know, the tree could have chosen me. For a moment, the buckets hanging from spiles on the trunks and the fluttering neon field tape both became temporary maps of my presence within the forest.

Incorporating mapping into the maple's story also reveals how climate change has impacted growth and decline over larger areas, through remote-sensing snapshots. Studies such as the Cornell GIS assessment of sugar maple habitats, show shifting habitat ranges from 2007 to 2019. Rising temperatures and precipitation observed in Vermont, New York, and New

[72] This open growth patch of trees has more sunlight available to the understory in comparison to a dense canopy forest, but nonetheless, the shade provides a niche for these forest floor plants.
[73] Wohlleben, *The Hidden Life of Trees*, 34

Hampshire, with changes to enhanced vegetation index (EVI) increase in some areas, and decrease in others.[74] A Vermont specific study used GIS and a calculated forest stress index (FSI), to show with emission projections, FSI will increase into the future, becoming less hospitable to sugar maple habitability. Another study, which Neil Pederson collaborated on, examined maple trees in the Adirondacks and found that tree growth decline was observed after 1970, and this decreasing growth accelerated after 1990.[75]

Sitting in the shade, I let myself think of the canopy's shadows as a momentary map, marking the relationship between the tree and the sun, the atmosphere, and the ground it takes root in. Based on the same ecological principles that allowed me to view trees as historians, I consider them as cartographers, their branches as maps. This abstraction is also a catalyst for emphasizing the various narrative qualities that maps hold. As the day passes, the branches elongate against an orange glow, the map projection becoming more and more distorted. Imagining the shadows cast by the trees as a map of photosynthesis in its inversion weaves in the necessary discussion of place.

[74] Li-Wei Lin, Hannah Goodson, Kate Markham, A.R. Williams, Marguerite Madden, Sergio Bernades, Kunwar Singh. (2019) "Identifying Environmental Stressors Impacting Sugarbush Longevity and Maple Syrup Agroforestry in the Northern Forest." Northern Forest Food Security & Agriculture II.
[75] Bishop et al, "Regional growth decline of sugar maple (Acer saccharum) and its potential causes," 2015.

Landmark

Forest compositions in the Catskills (above) and Adirondacks (below) during hikes in October. Maple foliage contrast with evergreens reveal large scale forest patterns.

In autumn, the maples become map makers, displaying the geology or human interaction in the brilliant red hillsides. On a hike in the Catskills with my friend, we paused at a clearing to gaze up at the crimson slopes. The maple forests were streaked horizontally with the occasional patch of evergreen, which revealed a striped pattern along the hillside. Perhaps this was due to old logging roads, which had filled in with pines, jumping at the opportunity to fill in the canopy. Or perhaps these patterns reveal the underlying geology, as the Catskill mountains are formed from a dissected plateau, revealing patterns of horizontally layered sedimentary rock.

Individual trees also exist as non-physical maps, as landmarks and borders.[76] If I give directions to North Campus, I describe the majestic sycamore (one of my favorite trees on campus) whose twisted, ghostly limbs stand out against the field. Linda Quiquivix writes of how the carob tree is a border, as Palestinians traditionally relied upon landmarks rather than paper maps. Here, the maples are borders, between the road

[76] Landmarks, I should add, are a source of direction, but they also can be a physical connection to the emotional or imaginative, especially during the act of *just wandering*.

and the Montgomery Place apple orchards. Beyond my patch, are both maple and locust trees extending in a straight line, creating a much more distinct border, accentuated by their size and age, indicating that these trees as historic points of land division.

Maples create temporary maps of hillside forest composition, revealing through contrast with pines, as well as standalone landmarks. However, they also help to create broader bioregion maps (Figure 7). Bioregions are defined not by political boundaries but instead by both the natural and cultural landscapes; circumscribed by area's climate, geology, natural history, watersheds, and the local geographies of flora, fauna, and human communities.[77] In *Braiding Sweetgrass,* Robin Wall Kimmerer describes Maple Nation, which is the geographical region where the leading citizens are the sugar maples: "the iconic beings who shape the landscape, influence our daily lives, and feed us – both materially and spiritually."[78] Personally, the patriotism for Maple Nation runs deep. The maple bioregion (Figure 7) includes the northeastern corner of the United States, extending north into Canada, across the Great Lakes Regions, and stretching southward in the peaks of the Appalachians. Maple Nation creates a medium for mapping a larger region of land, but one that does not have discrete borders or boundaries. This translates through my familiarity with the surrounding forests around the Bard area; the beech, maple, and oak forests remind me of the Vermont woods I grew up building forts in. And yet the sycamores and the abundance of locusts in the woods here are slightly less familiar.

[77] Bill Rankin, "Arborregions," *Radical Cartography*, 2016, http://www.radicalcartography.net/index.html?arborregions
[78] Kimmerer, *Braiding Sweetgrass,* 168

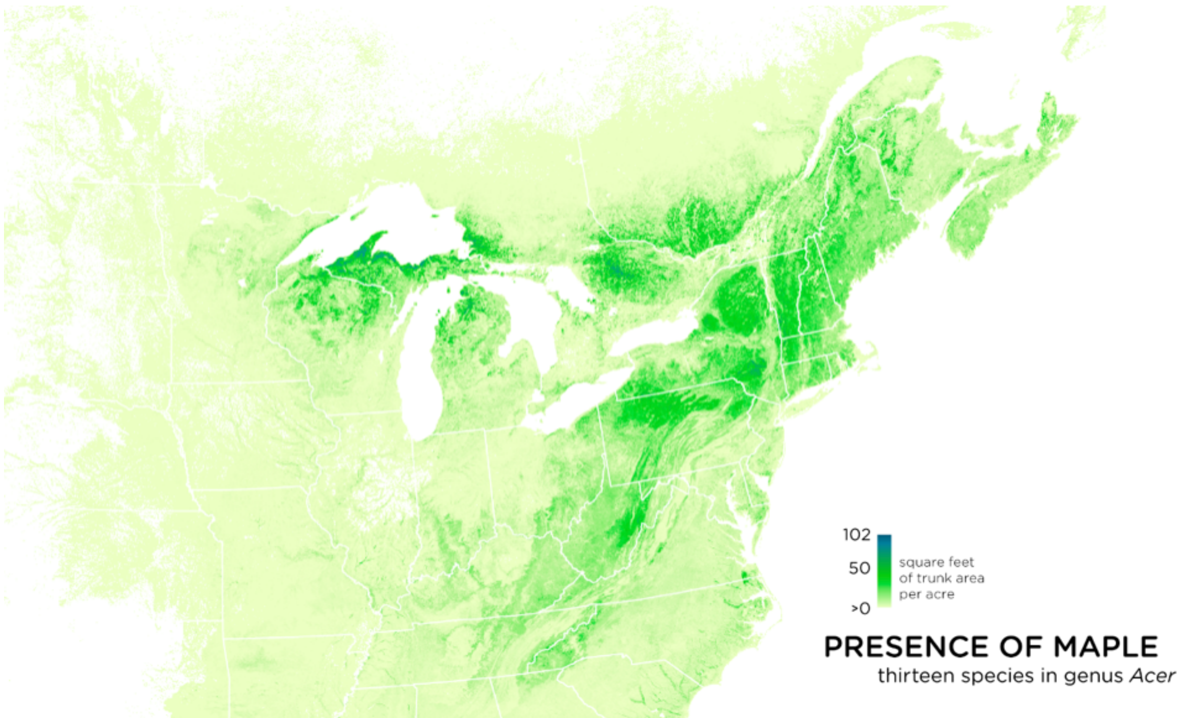

Figure 7. A map of maple species distribution, an excerpt from Bill Rankin's map TREES TREES TREES (2016) which shows relative distribution of tree types in the area that is the United States and Canada.

While maple trees exist further beyond these geographic regions, Maple Nation holds the land where sugarbushes are the most prevalent; where sap harvest time is the celebrated turning of the seasons; where sugar shacks dot the backroads, wood smoke billowing from their chimneys. In an interview for Voices from Maple Nation, an Indigenous Women's Climate Summit, Robin Wall Kimmerer shares that the maple is the convergence of relationships between humans, land, water.

The idea that the maple is a point of relationship is explored in various ways throughout this project, especially in relation to seasonal and climatic rhythms. Weaving in the ways in which maples are a nexus of relationship to land is particularly important, considering the larger historical context of my study area. For example, any map of the Montgomery Place old-growth forest holds the weight of Indigenous displacement. That is, place, beyond being purely physical, holds the additional weights of memory and experience.[79] Therefore, mapping Montgomery Place old-growth forest also requires me to reckon with its history and question what "conservation" means – especially in an area where old-growth forests are few and far between – on a plantation on Mohican land? Map-making, of course, has been used as a colonial tool, and often hand-in-hand with an illusion of ecological conservation.[80] Thus, maps provide a foundation for the construct of "wilderness," portraying the rift between culture and nature in a spatial format.

Indigenous Maps

Mapping, in colonial contexts, becomes a medium of asserting power, yet academic cartography often ignores other possibilities within mapping, as means to engage with the land through spatial narratives. In her paper *"Indians Don't Make Maps": Indigenous Cartographic Traditions and Innovations*, Annita Hetoeve˙hotohke'e Lucchesi presents examples of Indigenous cartography, showing how mapping mapping can exist, and *has*, independent of some form of relationship to colonialism. Lucchesi provides these examples in three categories:

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[79] David Bodenhamer, *Deep Maps and Spatial Narratives,* (Indiana University Press, February 4, 2015), https://doi.org/10.2307/j.ctt1zxxzr2, 3.

[80] Art, too, has been used as a colonial mapping weapon, as painters such as Thomas Cole perpetuated land theft from the Mahicantuk communities through their works. These paintings imposed hierarchy over the land in the composition of the trees, hills, water, mountains, and sky, and additionally portrayed settler illusions of "untouched wilderness" and "manifest destiny." Thus, art has the ability to weaponize, just as map making and scientific methods assert dominance over the environment – including, of course, the human communities as well. Language is of course entangled in this as well, as many languages do not have a separate word for the environment, as people are understood to be a part of ecology as well.

ancestral, anticolonial, and decolonial, per her own terminology. Additionally, she articulates how academic epistemologies of how maps can exist are limited by racial and cultural biases.

Ancestral maps were multisensory navigational tools, and forms of art. The carved wooden maps of the Kalaallit Nunaat, for example, were handheld representations of the shoreline and its topography.[81] They were buoyant, and could be interpreted in the dark, ideal for seafarers and hunters. Another example of ancestral mapping for navigation is in Polynesian shell maps, engraved with patterns of the stars.[82] Both Polynesian and Maya communities had archives of deep astronomical knowledge, and created maps in reference to the stars. These navigational tools are at their core, functional, yet they also situate the self within space through these map's levels of interactivity. The Shoshoni Map Rock, another ancestral map, is a petroglyph map, depicting spatial relationships of the local rivers – the Snake and Salmon – and the flora and fauna. This map situates the surrounding area in reference to local ecologies and landmarks.

While examples of ancestral mapping highlight the diverse and longstanding forms of Indigenous cartography, anticolonial maps arose in response to European settlers, thus establishing the practice of mapping changing landscapes and transitional life. Lucchesi's examples for anticolonial maps include Crazy Mule's maps and the Codex Quetzalecatzin, both of which documented the process of land theft under colonial rule and narrate this upheaval in relation to space.[83] Crazy Mule, a Cheyenne ex-scout and cartographer, archived narratives in

[81] Annita Hetoevėhotohke'E Lucchesi, "“Indians don't make maps”: Indigenous cartographic traditions and innovations," *American Indian Culture and Research* Journal 42, no. 3 (2018): 11-26, https://meridian.allenpress.com/aicrj/article-abstract/42/3/11/212114/Indians-Don-t-Make-Maps-Indigenous-Cartographic?redirectedFrom=fulltext.
[82] Lucchesi, Annita Hetoevėhotohke'E, “Indians don't make maps.”
[83] Ibid.

space which formerly existed as oral histories. The Codex Quetzalecatzin, one of the oldest documents in America, and represents Nahua survival and resilience under Spanish rule. The Codex incorporates traditional place-names, and is created using traditional Nahuatl techniques and plant dyes.[84] Lucchesi argues that these forms are the innovation of documenting genocide. Geographer Bernard Nietschmann writes that "[since] more indigenous territory has been claimed by maps than by guns, more indigenous territory can be reclaimed and defended by maps than by guns."[85]

As an extension of this, decolonial maps are contemporary means of reinventing practices of documenting and narrating Indigenous relationships to place. They are present day mediums for resilience and reinvention. One such example is the Zuni Map, in which Zuni artists use painting as a medium for mapping the cultural landscapes. Another example of decolonial mapping is "*Coming Home* to Indigenous Place Names in Canada" in which Dr. Margaret Pearce's, in collaboration with Inuit, Métis, and other First Nations communities, depicts place names. The labels are in their Indigenous languages, as well as in translation, which mark both ancient and modern places of significance.[86] The scope of this project does not cover, or attempt to speculate, on specifically Munsee or Mohican forms of mapping. Thus, Lucchesi's examples serve as a means to understand diverse ways of knowing and therefore narrating place, which can be applied to how we grapple with the history of our own local landscapes. The Zuni Mapping

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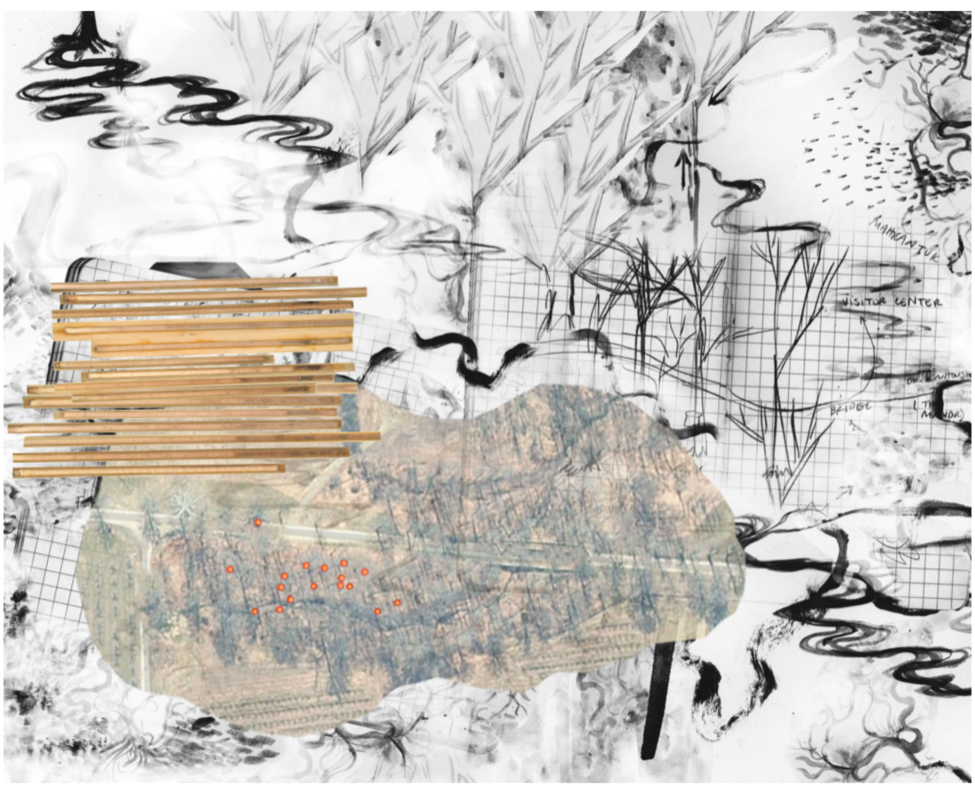
[84] Lucchesi, Annita Hetoevėhotohke'E, "Indians don't make maps."

[85] Nietschmann, B. Q. 1995. "Defending the Miskito Reefs with Maps and GPS: Mapping With Sail, Scuba and Satellite." Cultural Survival Quarterly 18 (4): 34–37. http://www.culturalsurvival.org/publications/cultural-survival-quarterly/193-fall-1995-cultureresources-and-conflicts

[86] Margaret Wickens Pearce, "Coming Home to Indigenous Place Names in Canada," Map, *Canadian-American Center,* (University of Maine)

Project and Annita Lucchesi's examples of diverse forms of Indigenous mapping serve as a way to understand how to engage and illustrate relationships with local landscapes.

Engaging with the land, especially in a historical context with the tree rings, evokes some sense of mourning. Emilio Rojas' *Hands to Hold,* summarized in the previous chapter, is an example of a map – in the loosest sense of the definition – or at the very least a practice of engaging with the land at a deeper level. This practice is also a lens into memory that the land holds, especially in places of pain and loss. The rings hold memories of a land stained by the legacy of colonization, as time flows in cyclic patterns through generations. Considering the history of Montgomery Place entangles another layer of complexity within the archives of the maple tree rings, where complete human records are either missing, or we are ignorant to them. The rings' abstracted memory also tells a story of loss, through the illegibility of the rings' archives.




Old trees die and become nurse logs, supporting the life of fungal, bacterial, microbial communities, insects and mosses. Other trees take root in the nutrient dense trunks of fallen trees. Fungal hyphae merge, creating an interspecies network of nutrient, water, and energy exchanges within
& within the swellings of tree root tips. Hidden within mycorrhizal architecture is the breath between what we consider living and what we consider non-living, as tree roots hug the land, and fungi aid decomposition of parent material and decaying organic matter. The binary between living
and what we consider non-living as tree roots hug the land, and fungi aid decomposition of parent material and decaying organic matter. The binary between living and nonliving is chewed away, leaving behind seedlings tp take root. The tree grows slowly adding memory in concentric ring
circles, growing ever wider. Becoming home to pileated woodpeckers, redback salamanders, insects, porcupines, lichen, and squirrels. Old trees die and become nurse logs, supporting the life of fungal, bacterial, microbial communities, insects and mosses. Other trees take root in the trunk
nutrient dense trunks of fallen trees. Fungal hyphae merge, creating an interspecies network of nutrient, water, and energy exchanges within the swellings of tree root tips.decomposition of parent material and decaying organic matter f eeding
breath between living and nonliving is chewed away, leaving behind seedlings to take root. The tree grows slowly, adding memory in concentric circles, growing ever wider. Become home to pileated woodpeckers and
redback salamanders, insects, porcupines, lichen, and squirrels.Old trees die and become nurse logs, supporting the life of fungal, bacterial, microbial communities, insects and mosses. Trees take
Old trees die and decay and become and become home and become decay. Old trees die and decay and become and become home and become decay and
Tree rings with rotted inner cores show how death is woven into life, as some wood decaying fungi will feed on the inner wood of the tree leaving
the outer rings to continue growing. And as a dead trunk, or a nurse log decomposes into organic matter, life multiplies
from the decay. Other trees take root in the land, hugging the soil, and remembering in rings
that hold the memory of growth and decay and growth and decay and
;ife multiplies from the log. Becoming home once again

Helicopters

An Artist Statement

The last time I went to visit the patch of forest, the forest had filled in with green, and the air was heavy with pollen and an impending rainstorm. Helicopters, the maples' seeds, hung from the branches, their delicate wings outstretched. In late spring, they will catch the wind and spiral down to the forest floor, scattering instructions to become rooted again. Where is the memory of flight contained, if not in the rings?

My art takes the exploration of tree memory further, simultaneously processing scientific findings and imagining non-human experiences – from winged seed to decomposition and back again – through multimedia sculptures. The confluence of art, science, and agriculture within this project are not coincidental, but symbiotic in exploring points of relationship between local ecosystems, humans, and the land, and the history embedded within them. My work attempts to capture the nexus of decomposition and growth in nurse logs as well as translate sugar maple memories of the land and climate change. These meditations on memory and decay are made physical through various forms of sculpture. The forest is made up of woven interactions, nested within each other, and are best represented through threads,

Tangling; Holding;

Weaving; Transmitting;

Fraying;

The world that has emerged, an imagination of symbiosis in the form of multimedia installation, is rooted in the same forest where I came to take cores as well as to listen, and is an exploration of entanglement, between insects, fungi, trees, maple syrup, humans, climate change, lichen, memory, place, thread, and sound. Queerness is woven throughout all aspects of this work, as I was influenced by the community knowledge of queer ecological philosophy. Queerness, to me, exists in the unspoken, much like the trees replies to my questions. Yet it persists, flickering through the sounds and smells of tree time and entanglement.

Suspended from a spile in the trunk, a transducer plays field recordings on a loop. They are the sounds of dripping sap, rumbling sap boil, birds, the cranking sound of coring, and the pièce de résistance: the sound of rotting heartwood, gas and water bubbling up, resonating in the increment borer barrel. Cords snake above the leaf litter, mimicking the mycelial networks underground, passing information to the transducers. The second transducer plays from a wax cast of a stump, another vessel within the installation. Sound captures the ephemerality and delicacy of ecological relationship, while thread holds the memory, and demonstrates entanglement in its physical form. Distorted language addresses the illegibility of memory. Woven and quilted textiles drape the forest floor, depicting translations of decay and tree ring memory. These themes are also depicted through an accordion zine, or leporello, which I consider to be a forest atlas, containing a series of abstract maps, distorted language, held together by threads. All the while, birds call to each other in the canopy, and helicopters spiral around us.


map, marking the rela
d me to grant agency to the
s as a map of photosynthes
des older have grown be
hole wells with sap until the wate
e perfect place to bend over, han
ge we do not speak, and we can only guess
both of which lead me
sun and the tree. Th
As the day passes,
sion weaves in the
ere the bark
s a map that creeps across the leav
g at the base of a tree, where moss and lichen clu
e composition of the understory, such as shade
process. And yet, trees are to some degree
This idea of forest upbringing reminds m
of the canopy's shadow
the same ecological
ried. Imagin


1900
1910
1920
1960
1970
1980
1990
2010
2020

List of Works

Figure 2. Quilted Tree Chronology
Fabric, batting, thread
Embroidered with COFECHA figure of relative maple growth from 1900 to 2022
3’ x 3’
2023

Stump
Wax cast of tree bark, chicken wire, yarn, maple seedling, (transducer)
18” x 12”
2022

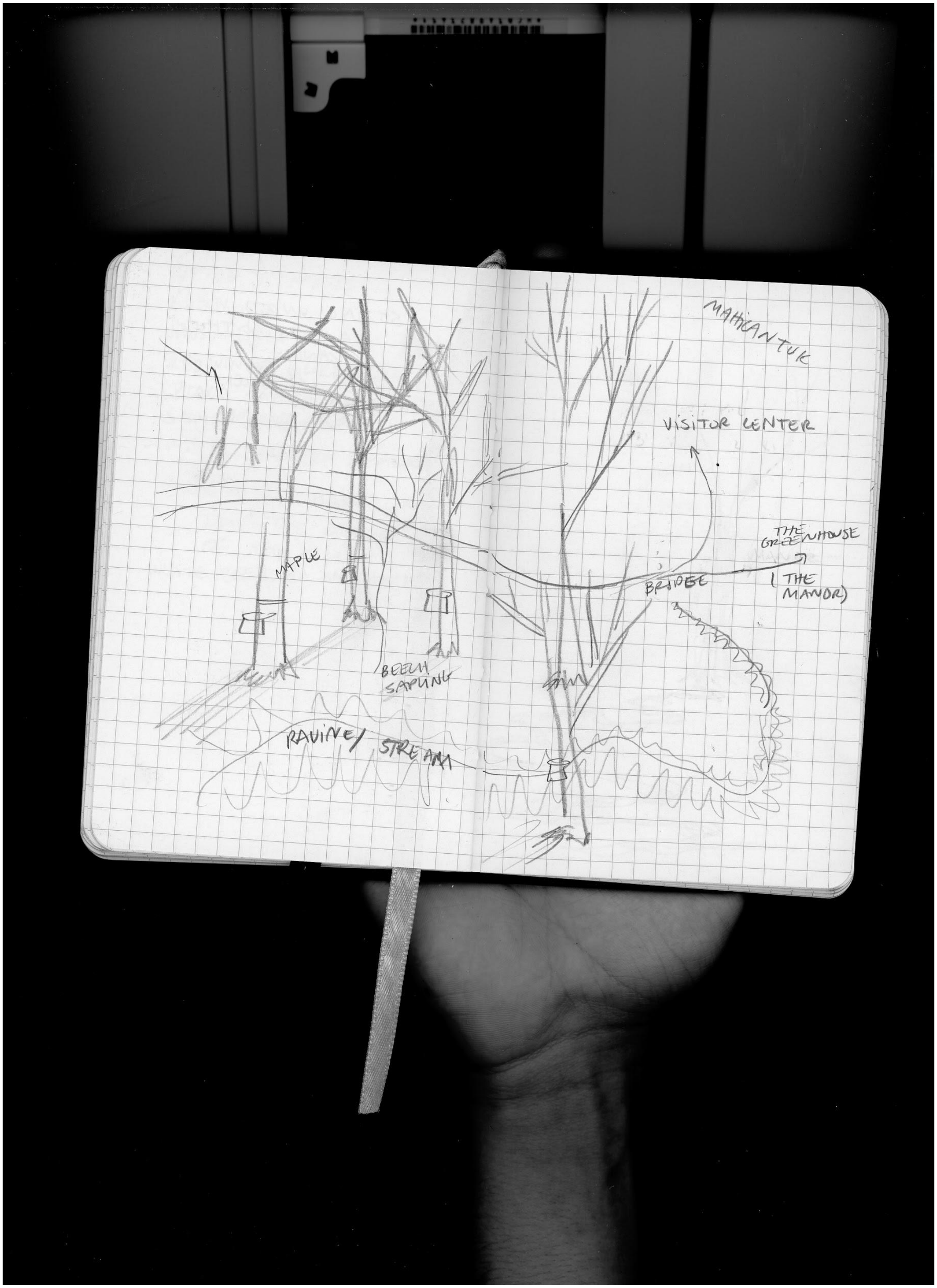
From the vessels
Field recordings, altered using Audacity
2023

weaving a rotten log
Woven thread, hand dyed with indigo, turmeric, and coffee
Performed as a graphic score for dancers and musicians
2022

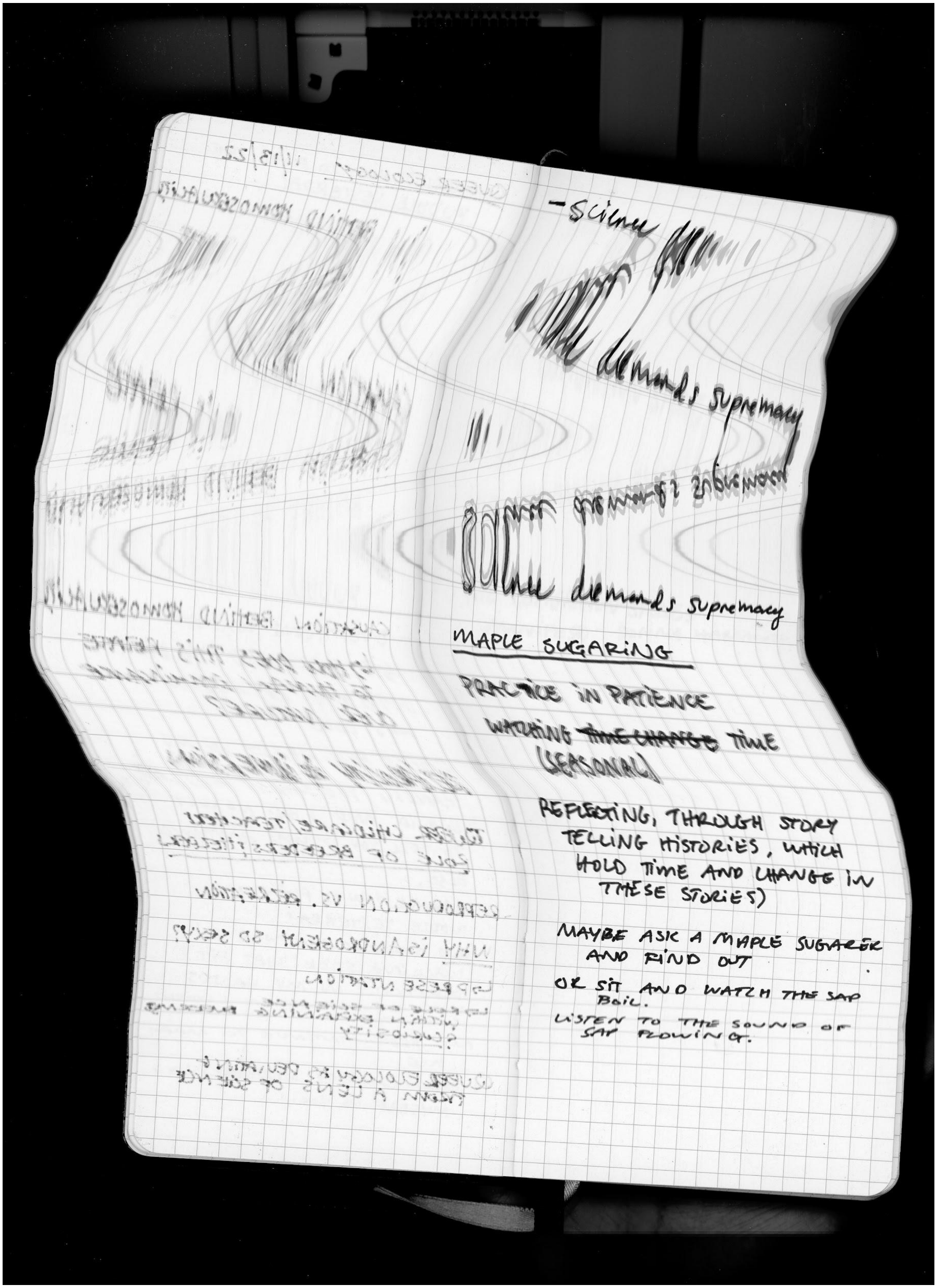
Leaf Litter Language
Found maple leaves, pressed, and laser printed with text from the body of work
2023

Cores
taken from the Maples
2022

Forest Atlas
Digital and analog collages of
scanned sketches, leaves, rubbings, paintings,
distorted text, abstract maps, thread
pencil rubbings of bug trails on fabric,
2023



MAHICANTUK
VISITOR CENTER
THE GREENHOUSE
(THE MANOR)
BRIDGE
MAPLE
BEECH SAPLING
RAVINE/ STREAM



-Science
demands supremacy
Science demands supremacy
MAPLE SUGARING
PRACTICE IN PATIENCE
WATCHING ~~TIME CHANGE~~ TIME (SEASONAL)
REFLECTING, THROUGH STORY TELLING HISTORIES, WHICH HOLD TIME AND CHANGE IN THESE STORIES)
MAYBE ASK A MAPLE SUGARER AND FIND OUT
OR SIT AND WATCH THE SAP BOIL.
LISTEN TO THE SOUND OF SAP FLOWING.

Epi*log*ue

I returned to the woods, leaving my bike at the foot of one of the trees, which are green again for the first time during this project. Still pale, the leaves at the tips of the branches are just beginning to unfold and saplings sprout from the soil in pairs of red, tender leaves, all tasting the first rays of sun. The newly photosynthesizing leaves slowly add another layer beneath the trunk, forming new memories right before my eyes. This outermost ring marks my own time in the forest, studying and contemplating these trees as another blip in the rings. These rings, however, cannot capture the memories of everything that has come out of this project; what is so beautiful about the imperceptibility around both human and sylvan perspectives is that they are mutually elusive to one another.[87]

I had no idea of the extent to which I would become entangled with these maples.[88] My original question was always of memory, concerning the impact of climate change on maple trees, yet the maple has become a catalyst for broader curiosities. And so I have come to consider my project as a decaying log, holding within it both seeds and fertilization for further explorations of geology, of memory and ghosts, of non-human perception.

In terms of the research, there are still many unanswered questions. For the dendrochronological facet of the study, I hope to extend the research, broadening the sample depth in order to get a deeper understanding of the relationship between climate and maple growth. One of the figures which I initially set out to make, but did not finish, is a depiction of how temperature and precipitation in the months of June and May change over time, and the

[87] I can only imagine a world where this project can be projected in volatile organic compounds.
[88] As Morton writes, in *Dark Ecology,* “Scientists are now beginning to figure out something we’ve known in the humanities and the arts for some time: one is entangled with the data one is studying.” (29)

association between changing climate conditions and ring width indices. The only iteration of this figure appeared on the chalk wall of Beate's office, and the errors in my R code. Further studies of the tree's chronology should also take the Palmer Drought Severity Index (PDSI) into account. The comparison between the RWI and PDSI was originally suggested by Cari Leland, but again, time got the best of me.

This project also revealed my curiosity into human relationships with the land, in many ways. For one, I would have liked to include conversations with the Munsee or Mohican peoples on their perspectives both on relationships to historical sugaring practices as well as broader connections to the land. Another ethnographic perspective I would have liked to incorporate is the voices of maple syrup producers around the area, to get a sense of their perspectives on historic and current sap flow, in relation to the climate. Additionally, in these conversations with maple sugarers, I would pose the question of how sap, to them, might be an actualization of relationship to the land, in the context of the Anishinaabe story of Nanabozho. I could continue to list what could sprout from this project, or the seeds which lived within my head that never came to fruition, especially when it comes to the artistic aspects of exploring these themes of tree-time.

The paper birch, on the other side of the hill, mirroring the maple, reminds me of all of the unheard songs out there. There it is again, the humbling and reassuring sense of imperceptibility. I carry this feeling with me when grappling with the future maple and human communities. I leave the story of the Birch, and the recurring image of the decaying log, as tokens of what is unsaid, unheard, and unknowable.

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