Herbs, Soil, and Health:
Beyond Human and Planetary Medicine

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Abstract

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This dissertation explores the relationships between the generation of medical knowledge and its connections to herbs, soil, and the study of living organisms. The dissertation explores the origins of medical knowledge by tracing the history and significance of medical concepts such as 'adaptability,' 'autopoiesis,' 'milieu,' and the 'normal' in physiology. An important direction and intended contribution are the discussions of methodological approaches to studying living beings in their milieu, guided by a discussion of vitalist and mechanistic approaches to understanding life processes, and a proposal to embark on a specific method of inquiry equipped with the possibility of such intellectual purpose: intuition. Health, conceptually, is also analyzed from a contemporary political context and the implications of ecological crisis on how health is conceived and practiced upon, on a more-than-human, planetary scale. Informed by the study of medical philosophy, the dissertation shifts into an application of intuitive methods

and a vitalist conceptualization of the living and its relation to its milieu, to explore soils, agriculture, and animal husbandry. Through a series of explorations of methods learned towards soil health, we propose that the idea of working towards planetary health, humans included, can be achieved optimistically by working for the ground, for soil and its life-giving potential, in what can be conceived as a medical agriculture that can set the planet on the path towards ever greater abundance of life, and health.

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PART 1 – INTRODUCTION, METHODS, OVERVIEW

1.1 Introduction

We ask ourselves in this study: how can we study and understand living beings –plants, animals, microorganisms– and the earth they are a part of?

We also ask: Is another medicine possible? and is another agriculture possible?

There is a continuous thread or loop that connects the climate and mineral characteristics of a valley or mountain, to the life inside the stomach of a mammal (a cow or a human, for example), to the physio-pathological processes that medical knowledge deals with. Microorganisms, roughly speaking bacteria and fungi, are found everywhere, but not at the same time or in the same distributions. Their presence in the context of the health-disease is recognized in many aspects, as is their presence in the context of cultivation and use of herbs (or food)[1]. They can be pests, plagues, and allies, and everywhere in between.

The connection of herbs and food with what we call "human health" exemplifies the close relationship of our bodies and functions (*health-disease processes*), with an engirding and encompassing planetary health[2] that both surrounds and embeds the boundaries of what we call *"our bodies"* and *"our environment"*. In particular, and for the purposes of this text, the main relations we will explore are those across *human health* with the *health of the soil*. Many *agro-ecological practices*[3] , old and new, conceive the health of the soil by analyzing and understanding the mineral/chemical and microbiological relations; likewise, particular medical models conceive and localize bodily processes and structures both physiological or pathological in their relations

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[1] For example, the emerging research of the human gut microbiome acknowledges that enhancing microbial species diversity in the human gut, mostly dependent on diet (i.e. soil microbiome), enhances host health. (Flint et al. 2012; Sonnenburg et al. 2016; Valdes et al. 2018).

[2] *Planetary health* not as the contemporary term/movement/ideological formation, rather health that is planetary, the health of the planet if we can see the planet as an entity, an organism, a being.

[3] I use the term agro-ecological based on the Spanish "agro-ecológico" as it used by many of the collaborators of this text, including myself. Other terms, with their similarities and differences, include organic, regenerative, permacultural, and many others. This text will examine these practices in greater depth.

to mineral/chemical and microbiological interactions[4]. For both views, microbiological and mineral/chemical relations work towards living processes such as a food producing space (or life producing forest) or a healthy living organism[5].

The proposed study is a *geography of health and its relations to herbs and soil.* The academic traditions we draw upon for theorizing health and medicine involve what may be covered under the broad umbrella of the philosophy of the life sciences, and more specifically, medical knowledge. This will require a conceptual review and analysis of the concept of human health, medicine, disease, and how healing is conceived in "the hegemonic biomedical model." To embark on this, we use the work that Canguilhem (Canguilhem 1978, 2008; Canguilhem, Geroulanos, and Meyers 2011) has produced and influenced with discussion of the main biomedical authors such as Bernard, Leriche, Bichat, Virchow, Bergson, and other mostly European (or Eurocentric) physicians and philosophers (Bichat 1809; Bergson 1944; Bernard 1949; Rose 1998; Philo 2007; Roudinesco 2008; Chimisso 2015)[6]. Canguilhem's work, together with authors in conversation with him, represent part of the debates that originated the scientific and knowledge basis of contemporary hegemonic medical science, as well as the basis of the critique of the science as hegemonic ideology. Canguilhem's work, we suggest, provides valuable insights and critiques of how a medical model can impact, and be a product of, social, cultural, and political processes.

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[4] Health of the soil is understood as ability to be a source of food and herbs, and to preserve, restore, or maintain recognized ecological processes, "Soil health is the vitality of a soil in sustaining the socio-ecological functions of its enfolding land." (Janzen, Janzen, and Gregorich 2021, 159). Physiological processes as ability to deal with surrounding environment or milieu (Canguilhem 1978; Almeida Filho 2001). Broad examples can be disease as infection of bacteria, liver failure due to chemical exposure, or macronutrient depletion in soils exposed to -cides (pesticides, fungicides, herbicides) and reduction of microbiological activity through the use of solubilized fertilizers (Urea, N-P-K, etc.).

[5] This two-way relationship between the dualities living/inert, or biological/mineral, human/not-human has a long tradition in being the subject of academic inquiry. Philosophy of science, more-than-human studies, Anthropocene studies, among others.

[6] The readers may ask, as we have, why this Eurocentric (French) focus? It is important, from our perspective, to focus on European theorists of medicine and physiology during the 19th century, as it was there and during that period of time, in particular in France, was when the basis of medical knowledge -as we conceive it up to present days- was constructed and eventually gained hegemony through medical education up to contemporary times.

How this model achieved hegemonic status *(the hegemonic medical model)* is key to this discussion as well, a connection that demands establishing relations to political, social, and economic processes that have been the focus of latinoamerican thinkers such as Illich, Breilh, Freire, Samaja, Granda, Menéndez, and others (Freire 1970; Illich 1976; Breilh and Granda 1983; Breilh 1986; Samaja 2003; Menéndez 2015). Critical Epidemiology frameworks, epicritic for short[7], as we understand them for the proposal, conceptualize medicine and health by historicizing societal structure (Laurell 1989); that co-creates itself across politico-economic systems (Breilh and Tillería 2009; Cuvi 2013; Birn and Nervi 2015); and that cannot reduce health and disease into a checklist of risk factors and deterministic viewpoints (Barreto, Almeida Filho, and Breilh 2001). From the epicritic academic tradition, health and disease are geographical concepts, as we will discuss, although conventionally epidemiology has conceived health and disease within a "static space that exists solely as an immense natural base for social life, linked only by external or ecologic relations, and one in which disease is physically distributed." (Argüello et al. 1991, page 91)[8]. This view of epidemiology (or geography), with space-as-container, parallels reductionist approaches to health, where health-disease is just a product of biological factors or determinants[9].

To talk about the social determination of health is not the same as talking about the social determinants of health, a category used by the old school of public health and by international health organizations. Nor is it a random semantic construction, used to refer to "the same thing" with a subtle innovation. The social determination of health is a conceptual category worked out especially in the currents of social medicine and Latin American collective health, which starts

[7] Termed in Spanish epidemiología crítica, or epicrítica, the term epicritic in physiology is defined as "relating to or denoting those sensory nerve fibers of the skin which are capable of fine discrimination of touch or temperature stimuli." We like complex words like this, so we are considering keeping the term epicritic to define the type of fine observation on the socio-historical processes that relate to the hegemonization of the modern biomedical model.
[8] Our translation from Spanish.
[9] Through this document, we conceptualize the practice of medicine as an entanglement of diverse *saberes* that have resulted through time, in places near and far, a range and diversity that are commonly overshadowed by what latinoamerican epicritic has termed the "hegemonic medical model". (Breilh and Granda 1983; Breilh 1986, 2008; Barreto, Almeida Filho, and Breilh 2001; Waitzkin et al. 2001; Krieger 2003; Coronado 2005; Cuvi 2013; Birn and Nervi 2015; Cueto and Palmer 2015; Solíz Torres 2015)

from a paradigmatic deconstruction of Western sciences and their way of understanding and explaining the world (Solíz Torres 2014, 33).

Faced with conventional and reductionist approaches, the critical paradigm in health maintains that the subject who investigates, the object of investigation and praxis all stem from a complex and multidimensional structure, which recognizes a space formed by three domains: general (society), particular (ways of life), and singular (lifestyles) which exist in a kind of dialectical mobility, sustaining relations of interdependence, interaction, and interinfluence (Solíz Torres 2016, 33).

These dimensions are related in a logic of determination and indetermination, understood as processes that have a defined way of becoming; this is a fundamental concept, since it differs from causal or multicausal approaches, insofar as it provides a scientific explanation of the genesis of processes, without falling into determinisms. Thus, critical epidemiology, from determination, generates an understanding of the way in which generative processes and their relationships occur; it starts from the notion of collective necessity with a vision of development; it has a conception of collective prevention: it multidimensionally anticipates and counteracts all destructive processes; it postulates a vision of collective promotion: it promotes protective and supportive processes; it is governed by an ethics of management with participatory forms of popular administration (Solíz Torres 2014, 21).

This incursion into the politics and history of medical knowledge and practice is key to maintaining the project as grounded and relevant to past and ongoing struggles for a counter-hegemonic medical practice. We propose working on soil health as a counter-hegemonic medical practice of planetary scale.

Discussion of the hegemonic biomedical model leads us to observe and describe how this same model of thinking, or method, is paralleled through other fields and sciences, by the contrivances of specialization that the same model has mastered. We focus on agriculture and soil science as another parallel of the same mode of thinking as with the biomedical model.

Then we can observe and describe the relations that this model acknowledges (or neglects) with *non-human actors,* such as herbs and microorganisms, or soil more generally. What is the agential role (Barad 2007) or the response-ability (Haraway 2016; Tsing et al. 2017) of humans with entanglements of matter, living or not? Contemporary publications from a wide range of sciences such as anthropology, sociology, science and technology studies, also inform the project in order to discuss the relational entanglements of health with that which is around us; or how we draw the line of us and our health. The key is that *we* do not forget that *we* are not the only kind of *we* (Kohn 2013, 72)[10].

In the case of these authors, and what we learn from them, is that *we* include all herbs and microorganisms, known and unknown, in the conceptualization of *us*. Paraphrasing Donna

[10] The readers may have noticed by now our use of the first-person plural pronoun for the narration of the text. We have tried to maintain this voice throughout the text, except for some sections below when members of the soil community find a voice, and when narrating personal encounters with some of our non-human key informants. A few reasons for this decision.

Perhaps the first one is a fascination with etymology, in this case of the Castilian word *nosotros (us/we). Nos-* First person plural, from Latin, plural of *ego* (I); and *otros-* from Latin *alter, (others)*. "I" and "others" in one single word.

Another motivation is this key framing by Eduardo Kohn, and Donna Haraway as well, referencing the importance of relationality and kinship across planetary beings. Kohn's framing is literally a call to action to rethink our worlds and what it means to be human. The following is the complete citation that will surely find resonating not only for this section but for further sections in our text: "What I mean is that the world beyond humans is not a meaningless one made meaningful by humans. Rather, mean-ings – means-ends relations, strivings, purposes, telos, intentions, functions, and significance – emerge in a world of living thoughts beyond the human in ways that are not fully exhausted by our all-too-human attempts to define and control these… If thoughts exist beyond the human, then we humans are not the only selves in this world. We, in short, are not the only kinds of *we*. Animism, the attribution of enchantment to these other-than-human loci, is more than a belief, an embodied practice, or a foil for our critiques of Western mechanistic representations of nature, although it is also all of these as well." (Kohn 2013, 72–73). As we will see in section 2.5 on Vitalism and Mechanism, we chose the word vitalism following Bergson and Canguilhem, but we could have used Lynn Margulis term Animism, as the antithesis of mechanism in the epistemology of life. We try to take Kohn's call to remember who *we* mean when we write *we* very seriously, and include in our narration the voices of mountains, farms, minerals, streams, and vats of microbiological brews.

In addition, we also take the use of this pronoun by emulating Georges Canguilhem, as he continually uses this throughout his work. Canguilhem's use of we/us/our instead of I/me/mine seems trivial, but if we were to speculate on his motives, as we haven't found any motive expressed directly by him, this move gives his narration and work a sense of respect to the academic traditions and thinkers that have come before. A recognition that our thought and writing is a legacy of past times, whether we are agreeing with or rebelling against them. Furthermore, we believe that our line of work is not just "mine," but that we are part of a collective of past, present, and future peoples that is constantly searching for another medicine, another agriculture, another world, a world with future. They come with us to the text.

Haraway, herbs and bugs as relatives, as kin (Haraway 2015, 161-162, 2016). Concerning ourselves with this implies that research and writing need to find a way of learning from such relatives, in a very personal, perhaps autoethnographic, approach. The intentional evaporation or folding of the boundaries of self and other, especially as it relates to biological determinations of body/environment, living/inert, or human/microbe, is a methodological move with a clear political intention.

Engaging with soil life is engaging self. This is the vitalist approach we will expand upon. Vitalism, seen this way, is used as a tool to overcome the war metaphor in medicine: microbes as the enemy. "A healthy adult human harbors some 100 trillion bacteria in his/her gut alone. That is ten times the number of "human" cells." (The Reimagining Resistance Group 2015, 20). For instance, if we recognize that microbial gene pools in our bodies represent 360 times more than our own "human" genes, "there is little doubt that our microbiome is an essential "organ" and not a mere invasive "parasite" that we need to "get rid off"." (The Reimagining Resistance Group 2015, 10).

Can there be a non-anthropocentric medical model? We claim, as Kohn does for his *anthropology beyond the human* (Kohn 2013, 2015; De la Cadena 2014; Latour 2014), that (human) medical knowledge will always be about the human, but the key distinction is in the method. From where we set our sight. What Barad, Haraway, and Kohn have in common here is their search for the relations of humans and matter or life beyond the "us" and "them" divide. They provide an example for us on how to *think* health and medicine beyond the human condition, on the relations of human health and biological life on all its forms, on how matter (minerals, elements, enzymes, microbes, plants, forests) is involved with medicine and the transformation of physio-pathological processes.

How can human health be conceived and understood by paying attention to soil health? How can an understanding of the philosophical origins of medicine inform a work on healing soils and environments? What is the nature of our relations (as humans) with the non-human actors that *engage in these practices of soil healing? How can we learn about herbs that help us transform our physio-pathological processes?*

As Anthropocene studies that observe and describe many forms or dimensions of planetary crisis of health (human or not) and ecology, how do we (humans) relate and interact with non-human agents in the generation, remediation, or acceleration of these/this crisis? These are all helpful example questions to guide our research, but as we do with the hegemonic biomedical model or with French philosophers, we are also critical of the context of such concepts (Anthropocene, more-than-human)[11].

As presented in the following sections that define our methods, this text narrates a study in geography that requires crossing boundaries of academic traditions as it demands on not settling

[11] Literature on the Anthropocene and more-than-human studies have interesting similarities. Plainly, the concept of the Anthropocene is as Eurocentric as the purpose of the more-than-human studies. On the inherent eurocentrism of the idea that we have entered into the Anthropocene, a good review is presented by (Morrison 2018), but we can also refer to Danowski and Viveiros de Castro's essay (Danowski and Viveiros de Castro 2014). In short, the fear that we have entered a futureless epoch at the end of times (Malabou 2017), with -Christianized- apocalyptic undertones is a fear shared by modern Eurocentric minds. Recalling Viveiros de Castro's statement: "The end of the world 'as we know it' is a distinct possibility. And when this time comes (it has already come, in my [Viveiros de Castro's] opinion) we will have a lot to learn from people whose world has already ended a long time ago — think of the Amerindians, whose world ended five centuries ago, their population having dropped to something like 5% of the pre-Columbian one in 150 years, the Amerindians who, nonetheless, have managed to abide, and learned to live in a world which is no longer their world 'as they knew it'. We soon will be all Amerindians. Let's see what they can teach us in matters apocalyptic." (Viveiros de Castro 2015, 6).

Similarly, more-than-human conceptualizations are required for those with a worldview that separates "humans" from "nature." The concept needs to be generated in order to overcome the divide of nature and culture, of human and not. As Mignolo argues, paraphrasing Philippe Descola (Descola 2013): "Briefly, nature and culture are two Western fictions. Many of us in South and Central America and, of course the Caribbean, began to understand that in ancient civilizations in Mesoamerica and the Andes, the binary opposition nature/culture made no sense. There was no equivalent for such words. If there had been, it would mean something similar to "it is the nature of our human organism that generates culture." For ancient Mesoamerican and Andean people and for those who survived until today, nature and culture are two meaningless concepts. How to get out of them is a decolonial question." (Mignolo and Walsh 2018, 160). The creation of the "human," therefore the creation of the "non-human," is theorized by Mignolo (and others with similar terms) as the foundation of the three pillars of the Colonial Matrix of Power: Racism, Sexism, and Nature.

Calling on both relatively recent lines of study -Anthropocene and more-than-human- as Eurocentric is not an intention by any means to take away any merits or place those authors under any moral questioning. It is just a matter of situating them; in fact, we take much from lines of work aligned to such traditions and will likely use them throughout our writing. Perhaps there are not so many conversations about the more-than-human outside Anglo-academia using the same term, but it can be a useful tool for translating concepts across academic languages.

on any specific methodology. We understand geography to be a discipline of multiple sciences, and therefore we will be dealing with agriculture, medicine, biology, microbiology, botany, physiology, chemistry, sociology, anthropology, and we are open to more -logies as the writing unfolds.

1.2 The method

The following section is a review of the method as we initially proposed it, and what guided the initial steps in this journey. Methodologically, we rely on readings and examples from a wide diversity of methodologies for scientific research, based on descriptive methods, qualitative or not, without any intentions to set out a deterministic analysis of the world. Based on previous academic work in the public health field, examples of methods familiar to us are mostly qualitative research methods (Denzin 2017; DeLyser 2010) including ethnography (Desmond 2014) and autoethnography (Anderson 2006) and grounded theory (Corbin and Strauss 2008; Charmaz 2000).

The debate on the more appropriate or accurate methodology for geographical work is vast, and although we have no intent on diving into its depths, there are some key concepts we can use to exemplify our proposed methodological approach. It has been argued that modern geographical research, from an Eurocentric perspective, has some of its theoretical basis on Kant's concept of History and Geography (May 1970, 238; Hartshorne 1958; Coscioni 2015; 2017). According to Hartshorne, "geography studies the world and describes and interprets different regions as they appear in a particular time. What other disciplines study as heterogeneous phenomenon, geography studies them in combination. By doing this geography puts together the aspects which other disciplines study in isolation." (Hartshorne 1959, 34).

Hartshorne argues for geographical research to avoid generation of laws on human phenomenon, and emphasize description over causality, which connects to the methods proposed for this project based on observation and description. The proposed methodology of description-as-method explicitly sets out to avoid generating laws or necessarily causal analysis, an analysis sought after by most of the natural or biological sciences as well as social sciences. To demonstrate causality an abundant number of cases is usually required, and geographical research limits itself to a limited number of observations, so it is not purposeful to formulate scientific research methods in those terms.

Humboldt and Ritter are commonly described as the founders of descriptive geography, as well as botanical geography (Hartshorne 1958; Nicolson 1996). Even more, due to their publications on Andean geography and botany (Rúales and Guevara 2010; Kunth 1823), they are somewhat local legends with their names on museums, streets, and monuments on the Andes. Their work, one that defined geographical work as a description of spatial/territorial patterns, were among the first geographical studies of the region we want to call our *area of study*: equatorial high Andes, pertinent to us is their work within the interandean valley on the San Pedro River basin, and the western slopes of the Corazón volcano. However, their work is what we can call bare description, a description that is not good enough for answering questions of relations, relations of people with their soil, with their flora and funga[12], with their health. In our case, this is only part of what description can give us as a methodological tool for answering questions about relations of people and health with their living milieu. We propose something called *description-as-method,* as an attempt to go beyond bare description, and for that we need to seek advice from other contemporary writers and philosophers, dead or alive. We set out to learn how to describe the relations of the world (of health more specifically) as we and plant/soil-people learn them from herbs and soil. This is not bare description, and though it does not have a definite name, we can call it creative description, poetic description, or description-as-method.

Karen Barad's book "Meeting the Universe Halfway" serves as inspiration for the methodological and epistemological framework we use. The book begins with the phrase, "This book is about entanglements" (Barad 2007). Description-as-method is also about entanglements. Entanglements of human health with the health of the soil and through the knowledge of herbs. Just as Hartshorne warns geographers to avoid making causality claims, description-as-method avoids generating laws or truth-claims of the objects of study. Nonetheless that does not mean that we are avoiding generating theory, as those involved with bare description usually do. Sometimes, staying clear of theory has been a common safeguard stance for making sure the research is complacent and complicit with the hegemonic powers (Escobar 2008). As Ananya Roy posits, generating theory is a task required to overcome hegemonic theories that intent to

[12] Funga is proposed term as part of the three Fs, Fauna, Flora and Funga, to highlight parallel terminology referring to treatments of these macrorganisms of particular geographical areas. (Kuhar et al. 2018).

impose a constructed, and commonly misrepresented, worldviews. "We must ask whether our dominant theory cultures are adequate in explaining the places on the map that are seemingly marginal and different" (Roy 2015, 201). A similar approach to Chakrabarty's proposal (Chakrabarty 2000) to look at European theories and problems as European theories and problems, not global ones.

Description-as-method is also an intentional re-appropriation of the concept of description, which, as Said argued, was the first "great collective appropriation of one country by another" (Said 1978, 84). Bare description has been part of the matrix of domination (Mignolo and Walsh 2018) by academia, as it risks validating the status-quo of existing power relations based in historical processes. "Colonialism itself is premised on the power of representing Other peoples and their worlds as 'not like us,' and thus in need of salvationary gestures like the 'white man's burden.'" (Springer 2017, 5; 2016) Description-as-method is not the same as bare description; it includes a possibility of creation and re-creation of the world we live, but also a description of a world that can be, of impossible worlds, of metaphorical stories, of creation of realities outside the hegemonic worldview.

This is not possible through a descriptive prose exclusively, but also though what has been dubbed geopoetics (Magrane 2015; Springer 2017). If the etymology of "geography" is "earth-writing", "geopoetics" can be "earth-creation" (Springer 2017). Geopoetics, as part of description-as-method, includes the possibility of the impossible, liberated from established ontologies, familiar epistemologies, and predetermined methods (Springer 2017, 16). How else can we dive into the relations of non-human actors such as herbs, or fungi, or the soil? If not through poetry, how can a geographer describe perceived, imagined, and impossible realities of the relations felt between human health and the health of a pasture? We do not fancy ourselves to be a poet, albeit we do write in poetry more for lack of enough literary or narrative resources. Fortunately, actual poets have come to our aid, and for the section on chromatography we welcome their help to contribute to this geopoetic effort.

The proposed method does not pretend to provide global answers or propose universals. Instead, we also follow Elwood, Lawson, and Sheppard's proposal to focus in relationality and their proposed three inseparable aspects: a socio-spatial ontology, an epistemological stance open to surprise, and a politics of possibility (Elwood, Lawson, and Sheppard 2016, 2). Three aspects that the readers will hopefully recognize through the current proposal. Walsh and Mignolo propose a similar approach to their decolonial academic work. "We are interested instead in relationality. That is, in the ways that different local histories and embodied conceptions and practices of decoloniality, including our own, can enter conversations and build understandings that both cross geopolitical locations and colonial differences, and contest the totalizing claims and political-epistemic violence of modernity." Further along, they state that "relationality also does not mean simply to include other practices and concepts into our own. Its meaning references what some Andean Indigenous thinkers, including Nina Pacari, Fernando Huanacuni Mamani, and Félix Patzi Paco, refer to as vincularidad". (Mignolo and Walsh 2018, 1). Description-as-method is a decolonial proposal. Overcoming the colonization of the mind, "this can be done only by means of the praxis: reflection and action upon the world in order to transform it." (Freire 1970, 51).

Based on all the previous discussion, we would like to present how we envision our proposal of description-as-method in our own (borrowed) terms. If geographical study can be, in one of its broadest senses and paraphrasing Hartshorne, the study of heterogeneous phenomena (human and/or not) as they entangle among regions of our earth (physical, functional, or imaginary), then the proposed methodology of description-as-method attempts to describe these phenomena as they appear (to us). However, a stand-alone, or bare, description is not enough to deal with the political and historical determination of these phenomena. Description-as-method involves an analytical and dialectical description of the political struggles and conflicts as well, both at an epistemo-ontological level as in material dynamics of domination-oppression in the conceptualization and practice of health and medicine. Description-as-method also involves the poetic creation of imagined and impossible realities, through metaphorical studies and language games that allow us to touch on what is beyond "us." This parallels the necessary theory-making proposed by counterhegemonic methodologies that allows the construction and proposition of alternative worldviews to the hegemonic paradigms. Description-as-method relies on narrating the entanglements across medicine and soil life and how we can learn from them in this search for what health is[13].

[13] At this point we would like to share with the readers a humble act of contrition, since it is on the political realm where the present dissertation has its weakest point. Although the proposed description-as-method approach is intended to be explicitly political in recognizing the political struggles at an epistemo-ontological level as in material dynamics of domination-oppression, we must acknowledge that there is where we have fallen short. We have failed in our attempt to deepen our descriptions (and actions) of the struggles of those on the oppressed ends of the dynamic of domination, as it relates to medicine and land in Ecuador. One excuse is that due to the covid-19 lockdowns context, our intentions of doing the work we have done with a larger participation of farmers from other regions were derailed. Another excuse is time and economic demands placed on us and our family, such that we needed to work on these studies in parallel of carrying out economic activities for our sustenance, therefore the work was done in places we work with and are responsible for. As a partial solution to this, we have tried to give a sincere reflection on the circumstances of our privilege in being landowners and inheritors in a country/region where this involves being benefited from a history of displacement and oppression of others. We are aware that this is not enough, it is not "praxis." As innumerable aspects through this project, we are leaving much unfinished work, this being the largest debt to ourselves and others. On *praxis*: "This [liberation] can be done only by means of the praxis: reflection and action upon the world in order to transform it." (Freire 1970, 51). This author, Paulo Freire, is a subtle but determinant influence of our political commitment in the work towards abundance and liberation. The following quote also reflects our intentions that what has been learned in this project (by us) is intended to be shared for those farmers and campesinos who want to work towards abundance in their own lives, with full confidence that it is them that know more about their own struggle than we do: "The insistence that the oppressed engage in reflection on their concrete situation is not a call to armchair revolution. On the contrary, reflection—true reflection—leads to action. On the other hand, when the situation calls for action, that action will constitute an authentic praxis only if its consequences become the object of critical reflection. In this sense, the praxis is the new raison d'etre of the oppressed; and the revolution, which inaugurates the historical moment of this raison d'etre, is not viable apart from their concomitant conscious involvement. Otherwise, action is pure activism. To achieve this praxis, however, it is necessary to trust in the oppressed and in their ability to reason. Whoever lacks this trust will fail to initiate (or will abandon) dialogue, reflection, and communication, and will fall into using slogans, communiques, monologues, and instructions." (Freire 1970, 66).

Description-as-method proposes to narrate the phenomena to include aspects of analysis (objective, mostly inductive reasoning) as well as an attempt of what Bergson calls *intuition*. In other words, a description of the entanglements, or spaces of relation across objects of study from our own positionality through what social sciences call reflexivity (Denzin 2017; Harding 2009; TallBear 2014); and a description of the objects of study by transporting the perspective of analysis to the objects of study itself. This last part is a partial and always subjective narration of the relations of living beings in their (re)creation of life, a poetic narration of relations of humans with their milieu.

Proposing intuition (in the Bergsonian sense of the word) as part of description-as-method is required to overcome the epistemological parameters we have used to frame the proposal, since it is unwise and philosophically unviable to propose to study life exclusively from the "outside" as a conventional deductive or inductive approach. This approach is essential to bring about any possible, and intellectually honest answer, to the question of what we can learn from our relations with the living to confront and overcome the crisis of homogenization and death in the collective work towards planetary health, towards abundance of life.

1.3 The path to the soil

An abundance in diversity of microorganisms in the soil is planned, desired, and designed by agroecological practices that health-mindedly prioritize this abundance as the key to their practice[14]. They attempt this by intervening within the particular interrelations of flows and processes with the elements: water, minerals, oxygen and other gases, and processes of life above and below ground (insects, animals, machines, geological forces). All of these without leaving behind the socio-historical context, political at its core, as the struggle to resist, contain, and reverse the hegemonic processes of domination and homogenization. Perhaps it is only about gaining autonomy and governance of their own lives.

In the context of the peoples that live within the Guayllabamba river basin in the northern Andes of Ecuador –including the city of Quito and its surrounding valleys and slopes– there exists an understanding and use of herbal medicines as part of everyday life, as well as with intentional medical purposes. People from a wide range of backgrounds and contexts design, create, and prescribe (as gift or sell as a commodity exchange) herbal preparations intending to modify or transform their health-disease processes[15].

Abundance of life below ground is abundance of life above. Abundance of life as we portray it is not an abundance in the quantitative sum of living organisms, or biomass as some like to frame it, but an abundance in kinds and ways of life and living. *Abundance of life* is a good enough[16] definition of health, of planetary health. To study abundance of life and its connections to health

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[14] We mention names and examples in the section of acknowledgements.

[15] Walk in a market in Quito and you will have plenty of herbal encounters, be recommended food as medicine, herbs as food, and a wide abundance of herbal recipes for any purpose. See encounter entitled "The urban market," another reference for this encounter will appear in the next subsection "Plant-people and soil-people."

[16] When discussing health through the years of medical practice and academia, we have been a witness of the difficulty people and institutions face when attempting to define "health." Eduardo Viveiros de Castro mentions the idea of the "good enough" description, borrowing from Deleuze and Guattari, David Graeber, Marylin Strathern, and other anthropologists, to make sure that the line of anthropological work he advocates – that line under the so-called "ontological turn" – maintains what he calls a "fundamental principle of what could be called the discipline's epistemological ethics: 'always leave a way out for the people you are describing'" (Viveiros de Castro 2015, 13). In our own reading of this statement, when we define health as "abundance of life," we are intentionally "leaving a way out" for the immense diversity of conceptions of health and living, avoiding totalizing definitions that inevitably leave us in the same mindset that we intend to avoid.

and medicine, we embark with conversations with plant-people, as well as with soil-people. In other terms, soil-people can also be people that study microbiology, in this case people working, among other things, with fungi and bacteria. Observing, describing, and reflecting on their work, as well as on our own work, is the basis of this project.

Human health, as soil health, as planetary health, is based on abundance of life above and below ground. If one of the definitions or delimitations of the scope of geographic work is the study of how things or processes relate to each other, across the planet, changing each other and the planet, then a study of the interconnections of medical knowledge to soil health practices is as geographical as a health geography can get.

Plant-people and soil-people

Herbs as more than just plants. However, *plant-people* sounded much better than herb-people. We borrow the term from Dale Pendell (Pendell 2010), and we think he would agree, we speculate, that it would be better to avoid a clearly defined proposition of exactly who or what might be these plant-people be or work with. He even claims that many plant-people may not even be aware of their relationships to plants and herbs.

Herbs as teachers. Herbs as doctors. Plant-people of the Andes speak of non-human *doctorcitos*. Usually spoken in these terms, with the diminutive –ito that emphasizes the caring and love that people feel for them. Plant-people are those who learn from them; describing and writing about their (herbs) lessons is part of the purpose, and the method. Some plant-people may work with countless plants, some may choose only a few, only one is good enough.

Through their knowledge and practices, and the transmission of their knowledge and practices, they actively explore and reshape their relations and flows within the body (excesses and deficiencies of our physio-anatomical processes: a preliminary definition of disease), the nutritional and microelement deficiency or excesses, between our body and our environment (so called “infections”, “intoxications”, “poisonings”, “trauma”), and across human-human and human-herb and human-soil relationships.

The visible presence of herbs for medicinal purposes in the markets through the Andes, even more in the markets of Amazonian cities we have visited, demonstrates that their use is widespread and common[17]. Evidencing a permanent presence of herbal medicine practitioners and people looking for herbal medicine also reveals that there are alternative ways of thinking about health and other ways of attempting to overcome sickness or regain health beyond the hegemonic biomedical model.

We have gathered descriptions of many herbal encounters in everyday life: unusual herbal preparations for spiritual healings, herb-based insect repellents to prevent vector borne illnesses, wild herb gathering while birdwatching, improvising a cure for a sick animal, among countless others. Herbal encounters are, sometimes, not about herbs. Additionally, as we wrote in the beginning of these subsection, herbs are not only plants. The reader will find some "Encounters" throughout as text boxes. They are intended to share journal entries of memorable acquaintances with our key informants that do not carry any particular reference to the text or portion of the text where they are located. Their purpose is to share some of the moments that the process of the creation of the text you are reading offered.

A particular approach to the question of how we transform or intervene in the physiologic, geographic, and socio-political relations within our bodies and/or environments (milieux) involves taking our gaze at a different scale of life: what biology and the life sciences have defined as micro-organisms[18]. Among (or around) those plant-people that grow and study herbs, there are those that concern themselves with the health of the herbs (or food) they grow and study by paying close attention to the dynamics, processes, structures, and flows of life that occur below, underground. Let us call them *soil-people*. These people work in close allyship to an enormous and virtually unknown diversity of life, microscopic life as we call based on our inability to see

[17] References on the abundant use of herbs in the region include (Gartelmann and Ortega 2011; Estrella 1995; Ortega 1988; Solis 1992).
[18] *Micro*-organism. The change of scale reflected in the prefix macro- or micro-. We recall Canguilhem's discussion of the prefix hyper- or hypo- as a conceptual tool used by the biomedical model in constructing the parameters of the normal and the pathological (Canguilhem 1991, 42).

Encounter 1 – The Urban Market

We arrived in Quito with a nasty cold, one of those common when under periods of stress, such as the accelerated transnational move we had carried out, and then being exposed to the multitude of global virus in the airports of the 13-hour flight from Seattle to Quito. It was 2018. Once we got settled in the center north of the city one of our first trips was to the Santa Clara market in search for some groceries, specially fresh fruit that we had been craving for the past 5 years. In the market we found moras for juicing, as well as babaco, tomate de árbol, and our personal favorite naranjilla. Wondering through the not-so-busy market in a Tuesday at noon, we found 5 places very close to each other packed with fresh herbs and jars of all colors and textures with signs like "Limpias", "Curación de espanto", "Para los Pulmones", "Para el Corazón", among many other tags. We talked to Betty and she immediately recognized the sore voice and congested breathing and said: "Usted necesita para la tos". We agreed and told her to give us some herbs that she thought we needed. She called for her young niece that came out from under bushels of herbs and told her to prepare a bundle of tilo, manzanilla, eucalipto and another herb we couldn't pick up the name. Betty told us to take this every day until they ran out, but with no further indication, as if assuming that its common knowledge how to prepare them and drink them. We know she meant for us to make an infusion. We also asked for some palo santo to smudge our new apartment and got our first house plants, a single pot combining ruda and aloe, a choice that Betty approved saying that the pot we chose had both male and female aloe, and that it's good to have them together with the ruda. Ruda purifies with its bitterness and Aloe welcomes with its sweetness. We were telling her that we will be coming back to get a full blown limpia but was interrupted by a cough attack that left us breathless. She cleared her throat while nodding and told her niece to add borraja to our bundle. She recognized that our cough had phlegm so that herb will help clearing that as well. While waiting for the change, (the whole bundle, incense, and plants was less than $3), we continued the conversation and she told us that she gets all her herbs from the San Roque market, a well-known wholesale market in the central old town that has a very rich history and ongoing struggles for their workers and surrounding neighborhood. We parted and continued our stroll through the market in search for some clay pots for our new housemates.

them individually[19]. The name microscopic is definitely a misnomer (or at the very least an interesting name), in the sense that the work done by soil-people for the presence and effect of these microorganisms is very visible and tangible. However, we also favor the name since it speaks of the necessary change in scale.

1.4 Overview

This closes the introductory section of this text, where we have attempted to present a review of the epistemological and methodological framework, and mark our lines of flight, or departure points. It may be prudent to advise the readers of what is coming ahead, or at least provide a scant overview of how the text was thought of when arranged in the present order.

After this initial introductory part (Part 1), the main body of the text is divided into two parts, and these

[19] For references to microorganism diversity and research on their functions as allies to plants and animals see (Mendes et al. 2015; Huergo et al. 2018; Bakker et al. 2014; Lakshmanan, Selvaraj, and Bais 2014; Schlatter et al. 2017; Stehouwer 2004).

parts in chapters, and some of these chapters also have subsections. Part 2 is entitled "Medicine and Philosophy" and contains the theoretical departure point of our project, trying to understand health and healing, and how life can be studied and/or thought of. We begin this by attempting a philosophical exploration of various concepts within medicine and biology: adaptability, normality, autopoiesis, milieu. Such discussions allow us to have some common language of what we mean by enormous, and hardly definable, concepts such as *health* or *life*. The intention is then to investigate the method of studying life, and a historical or thematic review of two broadly defined trajectories western thought has attempted. The two final chapters of Part 2 are tangential narrations of personal concerns we see with how health and medicine have been practiced and conceived in recent times. These two sections also embark on conversation with more contemporary authors than the main French philosophers that guide the bulk of Part 2. Many sections of Part 2 have been reworked from writings during graduate courses, yet all of them have been extensively redrafted, cited, and combined with new writings and reflections. Chapter 2.8 "Healthycology – health in times of … hyperobjects," is a transcript of a conference we presented for a virtual philosophy symposium organized by the Philosophy School of the Universidad San Francisco de Quito on May 28, 2020, during covid 19 lockdowns. We have tried to preserve the oral narration style for that chapter, and this is also the reason it's accompanied with images destined for a visual audience.

Then we go down the worm hole that is Part 3: Soil and Autoethnography. In this part we place some of the epistemological framework of Part 1, with the philosophical readings of Part 2, in practice, on-the-ground. We explore this ground literally, and we call it soil, the living soil. This part is subdivided into three chapters: soil, chromatography, and working with soils. The first chapter, 3.1 Soils, minerals, and microbes, was created out of our own necessity to learn more about a field of studies that was new to us, at least new in the systematic and technical way that was required for us to actually do the work of soil healing. The second chapter, 3.2 Chromatography, is an extended, revised, and redrafted version of an article published in 2022 (Andino and Espinosa 2022). This chapter deals with a method and practice that we encountered along the way while working on soil recovery and learning techniques for agroecological farming strategies. Chapter 3.3 shows a collection of recipes and experiences while working towards soil health. Such is the whole point of Part 3, doing.

Some acknowledgements – to people, places, and experiences

We will take this moment to acknowledge those who have helped and inspired us along the way. Some of them we have met personally, others have inspired us through their work. The main group of people that deserve acknowledgement for this text is the supervisory committee at the University of Washington: Sarah Elwood, José Antonio Lucero, and Steve Gloyd. Their support, patience, and guidance will always leave us in their debt. Most of all, my gratitude and admiration to Luke Bergmann as a committee chair, whose dedication and genuine interest in our intellectual adventures has been remarkable, and the generosity of his direction and encouragement decisive for anything valuable within this project.

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Beyond the agriculture worlds, it is fair to acknowledge people from medicine, public health, philosophy, and geography that also share some responsibility for how we live and think, and subsequently for what we have done here. Fernando Ortega, mentor from medical school days, who managed to open the eyes of the medical student beyond clinics, hospitals, and diseases. Jorge Luis Gómez, philosopher, friend, and life changing mentor, who managed to burst the bubble of reality and experience of what it means to think, someone who lived and died courageously and with brutal honesty and congruence with his vision. At UW we were welcomed with open arms by all the Global Health department and later by the Geography Department. Stephen Bezruchka has been there since the beginning of our time at UW and Seattle, thank you for your support and example of what it means to be a committed teacher and permanent student. We could name every faculty member, staff, or graduate student, but the list is long. Gracias. Special thanks to all geography graduate students that were there for us when embarking on a new path with few lights ahead.

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Our own experiences are too long to share, some will come through during the text of the dissertation, but at this point we will acknowledge the experiences that included brothers and sisters in this journey towards abundance. The first organized or self-conscious attempt to work with soils happened in 2010, as a naïve medical student, and it was baptized “Huerta 28 de Septiembre”, the date when we broke ground on an abandoned suburban plot with a group of lifelong friends. The perennial trees and a San Pedro cactus we planted then are now enormous, and wise. When living in Seattle, a group headed by a rogue artist from the Georgetown neighborhood joined a global health student when he was waiting on destiny to open a door to become a geographer and took over a parking lot with aims of turning it into a food forest. Many years before that there was a place called San Carlos, also in the Machachi valley, where we grew

up and had the privilege to be a child in a farm with no responsibilities other that play and exploration. Another thing that happened during our early years, and something we only recognized many years later as an adult, was that we were subtly but deeply influenced by indigenous knowledge and ways of life. In parallel, these experiences also sensitized us to the historical injustices towards indigenous peoples in the continent, and the cultural and economic subjugation they have been subjected to. We recall this place and attempt to be grateful for what it did to us when we dive into our memories of an old and controversial ally, the eucalyptus tree[20].

También tengo que agradecer a dos lugares, y con ellos a muchas personas que los habitan y trabajan, en tiempos pasados y presentes. A mis madre y padre, abuelas y abuelos, por haber querido a la tierra y darme la oportunidad de trabajar allí también, y a mis hermanos por ser como son. A estos lugares les debo todo, La María y Los Alpes, con toda la gente que ahí trabaja y que sin ellos no hubiera podido hacer nada de lo que aquí se ha escrito.

Finalmente, gracias a Verónica, for her love, and through her to Manuel and Mila. She is a non-recognized coauthor in everything I do, many times when I write *we*, it is *us* I am talking about.

[20] Chapter 3.3 Working with soils: trees, pastures, and animals.

PART 2 – MEDICINE AND PHILOSOPHY

In this section we open to a philosophical dissertation of medicine, and we do so as a departure point into our larger theme of health and life. Medical philosophy is a strange field, strange in that it is not studied in medical schools or by practicing physicians. We speculate that one of the reasons for the scarcity of medical philosophy is that its domain of study is as broad as humanity itself, as it requires an actual multidisciplinary approach. Writing about a philosophy of medicine can be intimidating when the student realizes the need of having to learn biology, history, anthropology, ecology, physiology (and pathology), psychology, and many more fields that touch, even if just tangentially, what it means to be human-in-the-world. We have resolved not to shy away from this challenge, but we do so cautiously. Loyal to our methodological approach, we will not attempt a final and definitive Philosophy of Medicine, albeit a partial and incomplete one. Hence, we do not start out with dogmas, theories, or hypothesis to launch our discussion; instead, by humble departure points based on concepts large enough to permit some depth of discussion, but practical enough to allow us to discourse towards practical and on-the-ground references (Part 3). We feel confident that this challenge, a study of a philosophy of a science made up of many sciences, is a fitting task for geography, also a science of sciences, and that through these efforts we may land on the interest fields of medical and health geographies, science and technology studies, relational and more-than-human geographies, environmental and agricultural studies, among others.

2.1 Adaptability, normality, and milieu – departure points

As promised above in the brief introduction to Part 2, and in our section 1.2 *Method,* we begin with a departure point of a particular concept about the living being, and we do so by tracing the history of how this concept has impacted our perceptions of what we think life is, and how life "survives": Adaptability. The idea of "adaptability" in the hegemonic biological model has an interesting history, in part due to the rich imagery that we can metaphorically and literally place on organisms "adapting" to situations here and there; an imagery imported into biology from the technical practices that humans and societies are constantly doing to modify their environments or situations. It is after all a confrontational connection between organism and environment. In this view, organisms relate to the environment as physical particles collide with each other in Newtonian physics. The milieu is then as an "already constituted fact and not as a fact to be constituted." (Canguilhem 1991, 283). In this analogy, if organisms are physical particles, then the environment is also responding to organism as they collide, even if the environment is 'larger mass' therefore seems to react 'less' in some sense (not in a momentum sense though). However, the analogy still stands when we think of adaptation as commonly understood within hegemonic biomedical science, because even if the larger mass that reacts to the physical particles colliding within it, we will approach a proposal that views organisms and its milieu outside analogies to Newtonian physics (purely mechanistic). Organisms and environments do not merely 'react' to each other's forces, but the milieu is constituted by the organisms that form it[21]. However, as we follow the trajectory of the concept within the hegemonic biomedical model, we see *adaptation* as a *tool* used by organisms to *fit* within their *given* environment.

Darwinian models submit the term, 'adaptation,' under the laws of *natural selection*, placing it in line with survival and transmission of genetic material to offspring; in short, adaptation as survival and reproduction *of the fittest*. Lewontin and Levins attribute to "Darwinian biology" the same issue that we, following Canguilhem, have placed under Claude Bernard's "experimental biology"[22]:

"For Darwinian biology the organism is the nexus of the internal and external forces. It is only through natural selection of internally produced variations, which happen to match by chance the externally generate environmental demands, that what is outside and what is inside confront each other. Without such a separation of forces the progress made by modern reductionist biology would have been impossible. Yet for the scientific problems of today, that separation is bad biology and presents a barrier to further progress." (Lewontin and Levins 2007, 31)

[21] More on this later, see chapter 2.6 Milieu.
[22] More on this later, see section on Chapter 2.6 Milieu and subsection "physiology beyond the human."

The milieu, Terrapolis in the words of Donna Haraway (2016), is created and inhabited by organisms and the elements, living together (*convivendo*[23]) in an ecology of beings, growing and composting[24]. Our health and our bodies are part of that open-ended system, and in those terms, what is "medicine" if not the knowledge and practices that can allow us to "adapt" to it? Adaptation of the organism with the environment is frequently described with two contrasting visions: teleological vs. mechanist in words of Canguilhem and animism vs. mechanism for Lynn Margulis (Canguilhem 1991, 284; Margulis and Sagan 2000, 5)[25].

The paragraphs above introduce three themes that are closely interconnected with each other if they are to have any coherence at all. Briefly summarized in three words and three questions: physiology, milieu, science; and: How can we study life? What is the relation between organism and environment? How does the living organism function and how can we (physicians, farmers, humans) act upon the living to achieve transformation? We aspire to develop these themes as the building blocks of a geography of health and medicine, as they will inform our practical and, quite literally, on-the-ground work on studying the health of soils, as the self-exploration theme that was grown out of the theoretical exploration of the philosophy of medicine. We could also word it differently, medical philosophy informed by soils and microorganisms.

Before and beyond the question of adaptation of the living organism to its reality (environment, context, milieu) there is a deeper question that arises. If we begin with the idea of adaptability, it is because of its relevance as a contested concept, proposed historically to represent, or misrepresent, life and the living being. But what is life? Similarly, the implicit question throughout this project (what is health?), we dare not answer it explicitly. It is a complex question to pose, and only a historiographic review of approaches to this question would take a lifetime. But for our current intentions of exploring a study of life and the living, let us approach with a brief synthesis of Canguilhem's biological norm and Varela's and Maturana's idea of autopoiesis.

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[23] From Latin *convitare*, combining *invitare* ("invite") influenced by *convivium* (banquet). In Spanish literally 'living together.'
[24] More on this later, see section 2.6 Milieu.
[25] More on this later, see section 2.5 Vitalism and Mechanism.

The concepts of the norm and the normal are fundamental in the history of medical science, our focus for this section, and we try to convey the complexity in trying to define this by tracing the path that Canguilhem has taken with the term. As Stuart Elden's review of Canguilhem (2019) presents, "the normal then is mutable, and adapted to context." (16). Approaching the term etymologically, "*norma* means a T-square, normal is that which bends neither to the right nor left, hence that which remains a happy medium; from which two meanings are derived: (1) normal is that which is such that it ought to be; (2) normal, in the most usual sense of the word, is that which is met with in the majority of cases of a determined kind, or that which constitutes either the average or standard of a measurable characteristic." (Canguilhem 1991, 125).

Canguilhem explores this concept deeply, and its implications reach far and wide beyond biological or geographical domains, mainly though his student Michel Foucault, and have impacted generations and mindsets in wide and profound ways in (post)modernity. Although it will surely escape our current analysis, we will explore it as far as it serves our analysis of adaptability and the connection of the living with its milieu. In numerous ways the "normal is not static or peaceful, but a dynamical and polemical concept" (Canguilhem 1991, 239). Dynamic because it is dependent on context and viewpoint, and polemical because "to set a norm (*normer*), to normalize, is to impose a requirement on existence, a given whose variety, disparity, with regard to the requirement, present themselves as a hostile, even more than an unknown, indeterminant. It is, in effect, a polemical concept which negatively qualifies the sector of the given which does not enter into its extension while it depends on its comprehension." (Canguilhem 1991, 239).

The expansion of the creation of the biological *norm,* with its subsequent jumps into sociology and culture, achieved hegemony and consolidation in Europe during the 19th century, although its roots are traced far before that and beyond that region. Through the conceptualization of the experimental method in medicine, we can understand how contemporary biomedicine faces the dilemma of knowing the living. By focusing on experimental method of European biologists (and sociologists) of the 19th century, Canguilhem provides the chance for an ecological reading on science and knowledge, and the ontological assumptions that western science has constructed, and is constructing in the laboratories of biological or other life sciences. The term biology, we advance, is used as the study of life, one that sustains the western scientific medical model, pathology, genetics, psychology, and many others.

This method has implications beyond biology, it is also not about animals, since although humans experiment on animals to try to understand the living, it certainly also experiments on humans. But it goes beyond humans and animals, the experimental method targets molecules, atoms, forces, spleens, embryos, coconuts, freudian slips, stock exchanges, and rocks. Canguilhem's choice of words and examples relate to his reference to Claude Bernard, whose rich work of physiological experiments has in his legacy the placement of positivism at the heart of the biological and medical sciences—as well as the personification of Dr. Moreau regarding his relationship with animals and his conviction for vivisection as the experimental method to understand the living body[26]. Canguilhem recognizes, as does Bernard, that there are particularities of the biological organism that escape experimentation as applied in the physical sciences. We will mention Canguilhem's four particularities of life that make experimentation on biological organisms speculative below[27].

This insistence on experimenting on the living body by François Magendie, and by his pupil Claude Bernard, as the only and best available means to understanding health and disease lies on the key assumptions that Xavier Bichat brought into western (in this case French) histology and physiology. This is what August Comte called "Broussais's Principle": all diseases consist of, for Broussais (and Comte who claimed it for social sciences and subsequently for the modern positivist medical imaginaries), essentially "in the excess or lack of excitation in the various tissues above or below the degree established as the norm. Thus, diseases are merely the effects of simple changes in intensity in the action of the stimulants which are indispensable for maintaining health. From then on, Comte raised Broussais's nosological conception to the level of a general axiom." (Canguilhem 1991, 47–48). This principle, absurdly simplified and reduced by Broussais, is better explained in Bichat's proposition conceiving life of the organism as a

[26] More details on this on section 2.6 Milieu.
[27] See section 2.3 Particularities of the living organism.

constant struggle to avoid death, constantly attempting to return to its "natural" or "normal" state[28].

"All curative resources have only one goal, to return altered vital properties to their natural state. All means which fail to diminish the increased organic sensibility in inflammation, which do not increase the completely diminished property in edemas, infiltration, etc., which do not lower animal contractility in convulsions and do not raise it in paralysis, etc., essentially miss their goal; they are contra-indicated." (Bichat 1809, n. cited in Canguilhem, The Normal and the Pathological)

If we are to overcome the obstacles of old theories, then new objects, theories, and even sciences might emerge that would be incomprehensible within the framework of the old theory. "As an example, Pasteur launched theories on microorganisms as the cause of putrefaction and contagious diseases. But to do this he had to overcome the obstacles in the medical philosophy of Claude Bernard. For Bernard a disease had to be understood as a lack or as an excess, and thus rendered any notion of disease as caused by organisms external to the body impossible" (Canguilhem 1988, Cited in Gamborg Lillebø 2013, 84).

But let us return to our epistemological concerns that guide the frame of this section with another question: How can we understand the "natural state" or the "normal" health of a living organism? To answer these question Bernard recurred to Bichat and its old axiom that the normal and the pathological are the same condition that differ in that the latter is a state where tissues (parts of the body) have been disturbed, augmented, diminished, or absent in their functional capacities. There seems to be a difference that Canguilhem recognizes between Comte's (Broussais) sociocentric and Bernard's (Bichat) biocentric perspective on the normal and the pathological. He states that Comte's thought moves from the pathological to the normal, with the intention to understand the normal. Comte's sociocentric approach wants to understand disease to construct the normal, which then applies to the "social organism" he also constructed. Bernard follows

[28] Canguilhem seems to use Broussais, famous also for treating every disease with leeches, as a way to talk about Bichat and Comte. He almost makes fun of him throughout and dismisses any value in his actual work, claiming that his is a naive and limited interpretation of physiology and positivist science of the time, best exemplified in Bernard and Comte respectively. He also seems to imply that Comte dogmatically took such an a-critical acceptance of his "principle" because it fitted well with justifying positive science and because of the personal relationship he had with Broussais.

more altruistic intentions, and for him it is important to understand the normal, by the way of the pathological, so we can bring the organism back to normal. “The identity of the normal and the pathological is asserted as a gain in remedying the pathological.” (Canguilhem 1991, 43–44).

The dogma that the pathological is a modification of the normal state implies that in the over stimulated or diminished organism or tissue that we can glimpse what the normal organism *should look* like. Physiology is dependent on pathology, and pathology depends on physiology; each one feeds on each other to find meaning and context. We assume that it is easy to recognize the “ontological trap” of the modern medical model. This is not a flaw of the model in itself, but it helps us recognize how these conceiving health and disease has expanded to other dimensions of human, social, animal, geological… in short planetary life. In fact, we could make the argument that this axiom has been key for hegemonic science. All models are vulnerable to such loops of meaning within themselves, and the biomedical model has expanded its influence on a vast network of fields and spaces based on such assumption. The hegemony of positivism testifies to this expansion of the reductionist dogma that found a biological justification in Broussais. He constructed the “social organism” by appropriating concepts of experimental physiology, which in turn intended to apply methods of mechanical physics into the living organism. We will not dwell much into the positivist jump of the “normal” from biology into sociology, but rather how the use of the experimental method, in part borrowed from the physical sciences, on the organism evidenced “particularities” that are worth noting if we want to discuss an epistemology of the living.

Understanding Canguilhem’s connections between these concepts—norm, adaptability, and milieu—is perhaps more relevant for our efforts than a dive into the individual concepts themselves, as he and others have dedicated lengthy reviews and reflections on them (Canguilhem 1991; 2008; 2015; Protevi 2011; Elden 2019). Discussing the concept of “anomaly” and “error” in evolution and physiology, Canguilhem states that “taken separately, the living being and his environment are not normal: it is their relationship that makes them such.” (Canguilhem 1991, 143). The example he presents are mutations on a particular butterfly that can have a phenotype of being either black or grey colored. In captivity, black butterflies have stronger bodies and wings, and eliminate the greys. In a forested environment, being black is a disadvantage as they stand out easier for birds to feed on them, while on an industrial setting with fewer birds, “butterflies can be black with impunity” (Canguilhem 1991, 143). The normality of this species of butterfly being grey or black is then called into question: it depends. Living beings adapt to their milieu and appear as normal. An idea constantly stressed by Canguilhem, and one we will return to repeatedly when discussing milieu generation, is that “a living being is normal in any given environment insofar as it is the morphological and functional solution found by life as a response to the demands of the environment.” Summarized in Canguilhem’s own words: “There is no fact which is normal or pathological in itself” (Canguilhem 1991, 144).

Encounter 2 – Carrizo, Suro - Chusquea sp.

Pionero de deslaves, iniciador del chaparro, colonizador de pastizales, protector de las quebradas y de los bordes. Fácil para incendiarte en la seca pero resistente a la humedad constante, donde cobijas las semillas y matitas del futuro bosque. Huésped de la funga más diminuta del bosque nublado, mohos, mycenas, y cuántos otros. Esquivas y no le llevas rencor al machete con tus rizomas, que sacan tus afiladas espigas tan rápido que casi se las puede ver crecer.
He visto brotes surgir cruzando invisibles por debajo de caminos de 4 o 5 metros de ancho. Constructor de domos y cometas, flautas, bastones, y puntas. Tengo pendiente endurar uno para entrenamiento.
No te comen los humanos quizá solo por tu abundancia, aunque siguiendo la tradición asiática con tu pariente el bambú se puede preparar buena sopa de tus brotes tiernos. Mascar tu caña no es dulce, pero refresca. Quizá por eso te aman tanto las vacas que están dispuestas a desafiar toda cerca por llegar a mordisquearte.

Image 1. iNaturalist. Observation of Chusquea Genus from Los Alpes, Ecuador. Observed on 3/30/2021. Exported from https://www.inaturalist.org/observations/72478177 on 7/6/2023.

2.2 Autopoiesis – an approach to the question: what is a living ____?

Now that we have discussed some of the key biological, and philosophical, considerations of some terms and concepts such as adaptation, normality, and an introduction to the broad idea of the milieu/organism relation, it may be useful to remind the readers that our intentions are to understand how we can study life and the living. Perhaps more importantly, we attempt to trace some of the theoretical underpinnings that are easily overlooked when we think of “medical science” or “health.” For that, we needed to find a way to discuss life: what is life? An unanswerable question but nonetheless an approachable question if we find the right departure point. Our departure point is once again a particular concept, autopoiesis. A concept originated by two South American authors that has already had enormous implications beyond biological studies, as it is being used to conceptualize cognitive processes and computational models for artificial intelligence. We will omit this ramification of the autopoiesis thesis, but instead begin by tracing how the idea of autopoiesis can help us explore the question of questions: what is a living___?

In a text that has received less attention than it deserves, Francisco Varela[29] and Humberto Maturana propose a description of autopoietic systems as living systems, and they attempt to prove it by “showing that autopoiesis either constitutes or is necessary and sufficient for the occurrence of all biological phenomena, if the proper non-determinant contingencies are given.” (Maturana and Varela 1980, 88). “Auto" (self) and "poiesis" (creation, production). The most straightforward definition of the term can be derived from its etymology, and it refers to the capacity of living systems to continuously generate and maintain themselves. This means that the structure and organization of living systems is not determined by external factors or conditions, but rather emerges from their own internal processes of self-production. In their book, Varela and Maturana focus on the principles of autopoiesis as a theory of cellular life. And since the term has been widely used out of context, in particular into social science and robotics, it is useful, as Luisi reviews, to emphasize what is not autopoiesis. Autopoiesis is “not an abstract theory, not a concept of artificial life, not a theory about the origin of life—but rather a pragmatic blueprint of life based on cellular life.” (Luisi 2003)

Examples of autopoietic systems include individual cells, multicellular organisms, and social systems such as families or organizations. In each case, the system is able to maintain its identity and organization over time by continuously producing and reproducing its own components and selectively absorbing and processing information from its environment. The relation of the

[29] We were introduced to Francisco Varela by John Protevi in the introduction to “Life, War, Earth: Deleuze and the Sciences”. (Protevi 2013)

autopoietic unit with its milieu is a dynamic one, and it opens the possibility that Darwinian[30] models would see as impossible, the organism affecting its milieu instead of being a passive adapter to its pressures. It challenges traditional views of living systems as passive, reactive entities that are shaped by external factors, and emphasizes the active, self-organizing nature of life (Fleischaker and Margulis 1986).

These authors present an autopoietic organization by a closed set of relations within this system, and these relations define a 'space' that can be realized as a concrete system (Maturana and Varela 1980, 88):

i. Relations of constitution. Constitute the topology in which autopoiesis is realized.
ii. Relations of specificity. Determines the specific components defined by their participation in autopoiesis.
iii. Relations of order. Determine that the concatenation of the components in the relations of specification, constitution and order be the ones specified by the autopoiesis.

The autopoietic process, they propose, is eventually embodied in a system that is necessarily physical, be it molecular, biological, or physiological [31]. “That a cell is an autopoietic system is trivially apparent in its life cycle. What is not trivial is how the cell is a molecular embodiment of autopoiesis.” (Maturana and Varela 1980, 90). The cell defines its constitutive relations through the production of molecules (proteins, lipids, carbohydrates, and nucleic acids) which determine

[30] Darwinian biology is probably not the same as Darwin’s biology, just like Marxist studies are not the same as Marx’s studies. The Darwinian biology we are referring to is more closely connected to Darwin’s heirs, such as Herbert Spencer -*social Darwinism*-, or August Comté -*positivist biology*-, or Claude Bernard -*experimentation in medicine*-, among others.

[31] We take this proposal with a pinch of skepticism, or at least with a need for clarification. It is common that when we think of a purely ‘physical’ system, we are omitting the possibility of life in immaterial dimensions. Like Eduardo Kohn’s analysis of the materiality of signs and the semiotic process. “…signs surely have an important materiality: they possess sensuous qualities; they are instantiated with respect to the bodies that produce and are produced by them; and they can make a difference in the worlds that they are about. And yet, like the space delimited by the walls of the flask, signs are also in important ways immaterial. A glass flask is as much about what it is as it is about what it is not; it is as much about the vessel blown into form by the glassmaker—and all the material qualities and technological, political, and socioeconomic histories that made that act of creation possible—as it is about the specific geometry of absence that it comes to delimit.” (2013, 35). However, we can agree with the statement, also spelled out by Kohn, that “although semiosis is something more than energetics and materiality, all sign processes eventually “do things” in the world, and this is an important part of what makes them alive.” (34)

the topology of the relations of production in general. “The cell’s relations of specifications are relations that determine the identity (properties) of the components of the autopoietic organization, and hence, in the case of the cells, its physical factibility (…) In the cell such relations of specification are produced mainly through the production of nucleic acids and proteins that determine the identity of the relations of production in general. In the cell this is obviously obtained, on the one hand, by relations of specificity between DNA, RNA, and proteins, and on the other hand, by relations of specificity between enzymes and substrates. Such production of relations of specification holds only within the topological substrate defined by the production of relations of constitution” (91). Finally, relations of order are those that “determine the dynamics of the autopoietic organization by determining the concatenation of the production of relations of constitution, specification and order, and hence its actual realization. (…) In the cell, relations of order are established mainly by the production of components (metabolites, nucleic acids, and proteins) that control the speed of production of relations of constitution, specification and order.” (91)

They go further in, after observing that these relations (constitution, specificity, and order) are not unique to autopoietic or living systems, that the origin of an autopoietic system is still in question. “This problem”, they argue, “is not a chemical one, in terms of what molecules took or can take part in the process, but a general one of what relations the molecules or any constitutive units should satisfy.” (Maturana and Varela 1980, 93). The autopoietic system, as a unity, is defined “by and through its autopoietic organization.” No reference to Leibniz in their text, but in the editorial preface of the book, there is the following quote which is revealing about their approach in a number of ways: “In effect, Maturana and Varela propose a theoretical biology which is topological, and a topology in which elements and their relations constitute a closed system, or more radically still, one which from the 'point of view' of the system itself, is entirely self-referential and has no 'outside', Leibnizian for our day.” (Cohen and Wartofksy, in Maturana and Varela 1980, v).

There is a section coming ahead for the reader entitled ‘Vitalism and Mechanism,’ where we will trace the story of a historically lengthy debate on two visions of life and existence, but through this section we have already begun to hint at it. The preambles mentioned in this section about such debate have the purpose to let the reader know that, while we may agree or incline ourselves more with one of those 'sides,' our main goal is to avoid falling into the labelling trap of being a 'vitalist' or any other term. Varela and Maturana write about an "autopoietic machine," as they define it, within a "closed system;" concepts that are defiant and revealing for us since it challenges the stances of the different dogmatical camps within academic traditions. We venture to say that, despite their use of these terms, their approach is not mechanistic, and their view of a closed system for the living is not sympathetic with the experimental method of the sciences applied to the living[32]. In short, they show evidence that the problem of *mechanism* or *experimental* is not linguistical or semantical. What we propose, and will expand in further sections, is that there can be a conceptualization of living systems as machines, without giving way to a mechanistic conceptualization of life.

Calling an organism a 'machine' does not mean we see a living being as we see a toaster. Maturana and Varela write about this explicitly: "That living systems are machines cannot be shown by pointing to their components. Rather, one must show their organization in a manner such that the way in which all their peculiar properties arise, becomes obvious." (1980, 78). Furthermore, they describe this "autopoietic machine" as a type of machine that can be homeostatic, where "all feedback is internal to them. If one says that there is a machine M, in which there is a feedback loop through the environment so that the effects of its output affect its input, one is in fact talking about a larger machine M' which includes the environment and the feedback loop in its defining organization." (Maturana and Varela 1980, 78). A machinery of machines that recreate machines—and this is not a dystopian statement, as we are talking about the autopoietic machinery: life.

It is our intention that by now the reader has noticed that our exploration of autopoiesis is but a departure point into the study of life, including the language, analogies, and metaphors we might use to understand the living. Besides the previous argument that the idea of conceiving the living

[32] In the following sections, particularly on section 2.5 Vitalism and Mechanism, we will explore these terms more in depth.

as an autopoietic machine is not necessarily a mechanistic approach, the other argument that we take as crucial from Varela and Maturana's autopoiesis is the idea of a living (autopoietic) system as a self-referential closed system. Viewing life in these terms is not necessarily supportive of the idea that we can study life in a vacuum. A key aspect of autopoiesis is the idea of closure, which refers to the ability of living systems to maintain their boundaries and identity over time by selectively absorbing and processing information from their environment. As Thompson writes, "the self-transcending movement of life is none other than metabolism, and metabolism is none other than the biochemical instantiation of the autopoietic organization. That organization must remain invariant – otherwise the organism dies – but the only way autopoiesis can stay in place is through the incessant material flux of metabolism. In other words, the operational closure of autopoiesis demands that the organism be an open system" (Thompson 2009, 85). In other words, living systems can distinguish between what is relevant and what is not relevant to their survival and reproduction, and they use this information to maintain their organization and structure. This is different from experimenting on living systems as we do on physical particles, with the required "all else being equal" of a closed system. This critique of experimental methods of living systems is, as the reader will have noticed, repeated in many aspects through our text.

In Donna Haraway's book Staying with the Trouble – Making Kin in the Chthulucene (2016) chapter three –Sympoiesis– begins with a presentation of this term, sympoiesis, in contrast to autopoiesis. However, her analysis agrees with the conceptualization of autopoiesis as Francisco Varela presents it. "Nothing makes itself; nothing is really autopoietic or self-organizing" (58). Autopoiesis, says Francisco Varela, cannot be the end (or first) concept to understand all biological phenomena, because autopoiesis only characterizes living systems as autonomous entities that can be distinguished as composite entities through neighborhood relations.

"An autopoietic machine is a machine organized (defined as a unity) as a network of processes of production (transformation and destruction) of components that produces the components which: (i) through their interactions and transformations continuously regenerate and realize the network of processes (relations) that produced them; and (ii) constitute it (the machine) as a concrete unity in the space in which they (the components) exist by specifying the topological domain of its realization as such a network." (Maturana and Varela 1980, 78–79)

The huge diversity and totality of autopoietic individuals (the living organism) implies that there can be a hierarchy across autopoietic processes. This hierarchy is the subordination of the parts to the condition of unity. Autopoiesis makes a system living, a living unit. These units create, through symbiotic relations, the milieu that is the ecology of beings (alive and inert). If autopoiesis is not the starting point to understand biological phenomena, health and disease at heart of it, perhaps a better departure line is what happens in this milieu that is made up of autopoietic units and matter.

ENCOUNTER 3 –THE LIMPING COW – AND THE ENCOUNTER WITH SAUCO

We had already seen people using herbs to treat animals of various illnesses or to prevent them. For example, people that grow cuyes (guinea pigs) use marco as an insecticide and to prevent lice. We use water infused with eneldo, manzanilla, or oregano for calves with diarrhea.
Although many recur to biomedical alternatives from veterinarians and commercial husbandry product stores, it is usual to see that the first, or last, line of action for animal health is to use, just as it is for human health, what is around and available regardless of the medical model it may be based on. Since the 1950's, the research of Ecuadorian scholar Plutarco Naranjo points to the idea that the traditional indigenous medical models, herbal medicine among them, have been embedded or entangled into cultural habits and into the practice of the contemporary biomedical model. This encounter reminded us of that. A cow of about 1 year of age was limping badly from a hind leg. The knee joint was visibly swollen and hardened, while the pain was also visible as how the cow avoided to step on that leg at all. The people working there, it was in a farm we were visiting, said that it was not getting better despite their efforts of draining the abscess and rubbing it with menthol-based ointments. They also mentioned that they have been constantly "injecting" the animal with products they had in the farm, but we couldn't confirm their names, very likely antibiotic and anti-inflammatory medications of various kinds. After looking at the cow and feeling the knee once more, they agreed that what was needed was something to "soften it up" so that it could drain and begin to heal. They called Lucía, who tends the garden of the farm to give them a hand in making a poultice for the infection. We took the opportunity and joined her and walked across the garden and the nearby pastures finding some herbs she said might work for "draining the heat" and "soften up the inflammation". We looked for hierba mora and pacta first, as the ones that have their main uses for wounds and infections, as she said. Then we kept walking around and she was very happy to unexpectedly find some sauco. Then we added hierba de santa maría and grain salt to grind them all up and wrap with it the young cow's knee. We don't know the results of this therapy, but we gathered some sauco seedlings during the experience and transplanted them to our garden which are now mature trees, with a reminder of their use in heat draining poultices.

Image 2. iNaturalist. Observation of Sauco, Solanum genus, from La Maria, Ecuador. Observed on 3/15/2021. Exported from https://www.inaturalist.org/observations/71839075 on 7/6/2023.

2.3 Particularities of the living organism

We have previously hinted that, through the generation of medical philosophy and a theory of life and health, some necessary observations arise that require explicit clarification. These observations rely on the fact that, though life is a strenuously hard concept to define, we can describe what similarities run across those who live. Canguilhem discusses a set of particularities of the living organism that make any study of life speculative and signal the limits of biology. They will be useful for subsequent discussions we take on relevant aspects of our attempts to map more connections of life and the living towards our fundamental questions.

These are: (1) the specificity of living forms, (2) the diversity of individuals, (3) the totality of the organism, and (4) the irreversibility of vital phenomena. (Canguilhem 2008, 11). Let us walk through each of these. Living beings are unique in themselves. They may begin as identical, but the same organism is not only unique in relation to others, but it is also unique (an in-divi-dual) in relation to itself in a different time and place. Five-year-old Juan is different from thirty-year-old Juan. This also points to the fourth particularity, life flows towards death, and this is a one-directional road that no living organism can avoid. Bones will not return to cartilage and the liver will not have a cardiovascular function as it did when it was connected to the placenta, and the placenta is now recycled into who-knows-what. Not only are organisms unique and individualized, therefore generalizing knowledge acquired from experimenting on one is not possible, but we must remember that vital phenomena occur within inherently 'open systems' where external variables cannot be controlled as the 'closed' system that experimentation demands.

These "particularities" bring about reflections across themes and concepts that exemplify the speculative nature of knowing life. We rely, for now, mostly on two discussions: the dogmatic boundary between an organism and its environment (milieu), and the debate between a mechanistic and vitalist conceptualization of the living organism. The third mentioned particularity of the 'totality' of living organisms is interesting in this regard, and plenty could be explored by discussing the hegemonic doctrine of the mechanistic explanation of life and the living. These help us to understand the concept of milieu, or environment, and how the living and the inanimate are embedded in its creation and continual change.

2.4 Intelligence, intuition, and the method to study life

With the previous three sections of Part 2 we have set up the basis for further exploration, and that will surely be incomplete even when the reader reaches the end of the entire text. However, it is our hope that the narrative order of such explorations allows the reader for some sort of orderly flow of ideas spawning from our departure points. The end goal will not change, we want to understand health and life, and for that we need to explore how that can even be possible. In the section that begins now, we will tangentially begin with a short reverie of a moment that sparked what you are reading now. Next, we will explore a philosophical proposition of a method we have consciously attempted to place into practice for Part 3 of this text. And then wrap up with a subsection of another tangent that begins to exemplify how this methodological approach—intuition— can be explored on a particular theme: time.

“To act, it is necessary at least to localize.” Those are the first lines in Canguilhem’s chapter 1 - Introduction to the problem- of the book, *The Normal and the Pathological* (1991, 39). We recall reading those lines next to the bookshelf as we picked it up from the shelf many years ago and standing there in complete shock. Those words are the cause of this entire dissertation. Not being able to move, we dropped bags and other books and sat there in the hallway of Suzzallo library and kept reading. After years of deliberating internally with a (still unresolved) conflict of practicing medicine without being able to quite place a finger on why we felt uncomfortable with everything being taught and practiced, we realized at once, that what we had been failing on is to localize the source of our disconformity. It seemed that a key part of our discomfort was the fact that we wanted to help people; and medicine, as we were taught, was not really doing it. We have dived into politics and history, realizing that health was more profoundly impacted by political struggles, social inequities, and historical determination, than by a practitioner’s knowledge of signs and symptoms on the ailing body. This gave us textured knowledge, but it was still not cutting it, since the problem was still the person, there, in front of us, in pain or suffering, and our knowledge of the socio-political-historical determination was not going to help them either. It was also about how to recognize the signs and symptoms within the context of the sick person and how to deal with it [33].

This brief line by Canguilhem offered us the option to place a finger on the problem, although of course, not solving anything on its own. If we want to act on health, or on disease, or on historical injustices that determine the lamentable state of the health of people and territories, we need to localize the problem at its source, its origin, its roots. Paraphrasing José Martí, to be a radical is no more than this: to go to the roots. Of course, the problem remained. How can we think of localizing this problem? How can we think life, and health? We realized that localizing is not the same as thinking, but we have been continually trained as thinkers. Never satisfied with any route taken to this problem, we realized that we needed to understand more about what it means to think.

Then came another French philosopher, Henri Bergson, that in turn begins his book with the following phrase: "The history of the evolution of life, as incomplete as it may be, lets us see how intelligence has been constituted (…) It shows us this through its [intelligence] faculty of comprehending, an annex of the faculty of acting, an adaptation every time more precise, every time more complex and flexible, of the conscience of living beings to the their given conditions of existence." (Bergson 1948, 433).[34] We do not think it is a coincidence that the concern of those who want to understand life end up facing the problem of thought and mind. Maturana and Varela, for example, dedicate an even larger portion of their book to *cognition*, as the process that enables the functioning and self-organization of the autopoietic system.

Intelligence, in the restricted sense of the word, is destined to ensure the inserting of our body in its milieu, and to represent the relations among exterior (to us) things. Restricted, we believe, as used by Bergson to refer to the capacity of intelligence as the faculty of intellectual thoughts,

[33] Dealing with sickness is different than curing a sickness. Only the body can heal itself; a physician can only deal with therapeutics that deal with sickness. But that is a different discussion. Perhaps we can find the space in future writings to expand on this aided by more writings by Canguilhem, Gadamer, and Heidegger (Canguilhem 2011; Gadamer 1996; Heidegger 1995).

[34] We are mainly using Bergson's text in Spanish, so any translations to English are our own, unless the English or French editions are explicitly cited.

encapsuled necessarily by reason and with a unidirectional trajectory towards consciousness, also destined to fail in its attempts to explain all relations and processes (life among them) and aware of the imminent and even necessary failure. Intelligence, says Bergson, is destined to think matter.

Our thoughts and thinking processes, in their purely logical form, are unable to represent a certain notion of life, the true nature of life. Created by life in determined circumstances, to act on determined things ¿How can thought embrace life, if it is not more than an emanation or an aspect of itself? Or in the words of Canguilhem, how can biology claim to understand life if the biologist is a living being? There is always a dilemma of being both the object of study and being the subject conducting it at the same time. More importantly than this evident problem, lies the contradiction of modern sciences' claim to objectivity in its method, particularly when it revolves around life in general, or in the subject that most concerns us at the moment, medical knowledge.

Intelligence evidences that none of its conceptual categories (unity, multiplicity, mechanical causality, finality or teleology, etc.) can be perfectly applied to things that live. ¿Where does individuality begin and end, can the living thing be more than one? Our reasoning, that feels so comfortable among inert matter, finds itself uneased in this new territory. Life always surprises intelligence. (Bergson 1948, 434).

Anyway, when we recognize the limits of intelligence and its logical method, should we give up attempts to further deepen our knowledge of life? Consciousness has other routes or trajectories to understand evolution that, unlike intelligence, have not managed to free themselves from pressures external to them or from focusing on themselves. Such other pathways also carry knowledge or something essential about the evolutive movement. This is the key aspect of why intelligence fails when directing its aim at life: movement. Like the paradox of the arrow of Zeno[35], intelligence and reasoning can only see the now, the point, it cannot see the line and the

[35] With the risk of oversimplifying the paradox as described by Aristotle in *Physics*, this is the basis of the paradox and why it may be a good example of the limits of intelligence. Imagine an arrow in flight. At any given moment in time, the arrow must be in a specific position in space, such as point A. However, since motion involves a series of transitions between distinct positions over time, at any given moment the arrow must also be at rest. This seems to contradict our experience of the arrow as a continuously moving object. Furthermore, if we divide the arrow's flight into smaller and smaller increments of time and space, we can conceive of the arrow as moving through a series of infinitely small intervals. However, if each interval of motion is itself infinitely small, then it seems that the

flow of the object. What kind of knowledge on life could we conceive when we approach these different pathways of consciousness to intelligence? When discussing the experimental method of the biological sciences, Canguilhem poses that biology lies within a curious paradox. We hinted at this before. Biology claims that life is the object of its study, however we -humans- are part of the living that wants to study the living. Biology, and physiology in the specific case of medical science, has life as both object and subject of its knowledge. He proposes that this is not a hindrance in the study of life, but only becomes detrimental to the generation of knowledge if those studying life -biologists, physicians, etc.- forget that they are not exclusively objective scholars of life (Canguilhem 2008, chap. 1) .

The preceding citation by Canguilhem is taken from the first chapter of his book *Knowledge of life*, entitled "Method," and it is essentially a review of how the contemporary hegemonic biomedical model was constructed and how it sustains what it refers as generation of knowledge and discovery of scientific medical facts (how physiological and pathological norms are described). This paradox allows us to orient ourselves in the effort to localize the problems we are trying to face, a sort of cosmical positionality where we not only acknowledge our perspective based on ethnicity, gender, class, language, or other historic-socio-cultural categories, but also as a living being attempting to think about life.

Recognizing the paradox that Canguilhem observes, on life being both subject and object of the life sciences, we also pay close attention to Bergson's concepts of intuition, sympathy, intelligence, and analysis. For Bergson, it is crucial that we observe and practice a method that aids us in the task of thinking beyond the human condition. In his work *Creative Evolution*, he presents his method of intuition in contrast to intelligence (or analysis, depending on if we choose the Spanish or English language translations), as the method that can give us insights into life's processes. Intelligence, he claims, through the scientific analysis, will give us more and more

arrow cannot move at all, since it must always be at rest at each point in space. The paradox seems to be that Zeno was not able to realize that his reason was the limit. To "think" or "feel" or "understand" the arrow's movement, the perspective needs to shift into the arrows' perspective, instead of being from the observer watching the arrow fly. As we will see, this shift in perspectives, towards the inside of the object of study, is a good enough definition of Bergson's *intuition*.

knowledge (also a faculty of intelligence according to Bergson) on processes of matter and physics, but on life processes it is helpless of going into the secrets of life (or health, we might add). Intelligence revolves around the object, breaking it down into known parts and processes.

In contrast, Bergson will propose the method of Intuition. “Intuition is instinct that has become disinterested” -disinterested in itself; he presents instinct as sympathy towards life, as intelligence is to inert matter and self-reflective- "capable of reflecting upon its object and enlarging it indefinitely" (Bergson 1948, 591). Intuition is proposed as a methodological approach to understanding, not knowledge. Intuition is a method used mostly by the arts and philosophy, which can transport us into the interior of an object (be it physical object or biological phenomena). We intend to dive into the philosophy of life and health in search of what Bergson is trying to convey as the "very inwardness of life" and health.

Bergson claims that “an effort of this kind is not impossible, and this is proved by the existence [in humans] of an aesthetic faculty along with normal perception. Our eye perceives the features of the living being, merely as assembled, not as mutually organized. The intention of life, the simple movement that runs through the lines, that binds them together and gives them significance, escapes it. This intention is just what the artist tries to regain, in placing themselves back within the object by a kind of sympathy, in breaking down, by an effort of intuition, the barrier that space puts up between them and their model.” (Bergson 1948, 591). As Deleuze would put it “Intuition is neither a feeling, an inspiration, nor a disorderly sympathy, but a fully developed method, one of the most fully developed methods in philosophy.” (Deleuze 1990, 13). Perhaps we will expand on intuition, as Bergson describes it, as we elaborate on other themes where a call to this approach is required. We propose some practical approaches to this method in other sections[36].

[36] Particularly when discussing soil microorganisms and soil chromatography.

Encounter 4 – Mierda de llamingo - Llama manure

We were walking the pastures of the dairy farm in outskirts of Machachi with two agronomists that were collecting soil samples from the valley for biochemical analysis. This was before we embarked on soil analysis of our own. The farm only keeps female calves and sells most of the male calves as soon as possible. These male calves have a variety of fates, some more favorable than others. A woman that lived nearby in her sixties came with her twenty-something year old son to buy a calf that was born a couple days ago, but then also asked if she could go to the pasture where she saw a llama with some young calves to collect some manure. The agronomists asked curiously why she would be interested in such a thing, to which she softly said that it was for some curas. They grinned and continued their walk. We waited while she was collecting the manure and approached his son that was standing by the path holding the newly bought calf and was waiting for her mother. He was wearing clean tennis shoes and we suspected he wasn't very interested in the task that called her mother into the pasture.
We began a conversation about the plans they had for the calf, and he said that it was going to be "hornado" that her mother sells in the streets on the weekends. Not a favorable fate for this one. But then we asked about the llama manure, and he said that it was "para traer buenas vibras", for good vibes, by burning it with sahumerio. This word, sahumerio, is used to mean a combination of herbs into incense that are burn ritualistically for smudges and limpias. There are countless combinations of what people use to burn this and we were pretty sure that he didn't know what was in it, so we just stayed with that answer. He also said that her mother was very experienced in doing limpias and curas with herbs and incenses, but he knew nothing about it. We asked if he wanted to learn, and he replied that he is learning by watching whether he wants to or not. When the woman came back with a sack full of manure, we greeted her and introduced us, she did likewise and told us her name is Rosa. The conversation flowed easily as she told us about how she wanted to make a cure for a younger son, about 17 years old, that was "espantado", or with "susto", and that nothing was working. She brought up, unprompted, what we think is a common and overlooked aspect of herbal medicine and traditional practitioners (traditional as in using indigenous conceptualizations and practices of health and healing, in contrast to biomedical practice), that she had brought him to many doctors and that now this medicine was her "last hope".
As we listened in silence, she continued to share a long story of terrible circumstances that had fallen upon her family, including forced migration to eastern Europe by some of his sons, subsequent deportation, and many economic hardships that she tries to overcome by preparing the hornados on the weekends.

Life and death – reflections on duration and the pass of time[37]

The pass of time, duration, aging. These processes, or singular process, is constantly evidenced and observed in particular ways during soil work, and the connections we can see between what is evidenced in the field or forest with the pass of time in our bodies are remarkable.

[37] Although not directly referenced in the text, this reflections were inspired from our notes taken after reading Bergson's conferences on the "History of the idea of Time". (Bergson 2018).

Firstly, we see the pass of time, at least in our bodies, as aging. A unidirectional trajectory from birth to youth to maturity to death. The process of getting older is not only "growth," as the saying "birth, growth, reproduction, death." There is literal growth through the process, in youth your total body mass grows, bones grow, brains grow, and so forth. In old age there is also growth of a different kind, but we may say that growth is not the characteristic of this aging process later in human life. Note that we are not talking at all about the metaphorical "growth," a kind that is surely constant in human lives, growth of consciousness or experience. Perhaps we will find another moment[38] to discuss growth in more depth, with its relation to scarcity and abundance.

Interestingly, we also shall note that this unidirectional line of the (aging that) impacts of the pass of time on our bodies must be understood from both an external and internal perspective of our bodies. The pass of time leaves marks on our bodies that for the body itself are imperceptible, rather, we see evidence of it occasionally or circumstantially. For instance, we cannot perceive the gradual wear and tear of the cartilage in our joints until we experience pain in the knee after a long downhill hike. More interesting observations, to us, are those that remind us that our body has gained in strength and health, since these observations may be less evident or noticeable than observations where we have lost health or perceive the appearance of an illness. One example here that has happened to us, is how we have noticed that when we began doing active reforestation work in 2018, we could not dig more than 50 holes in a morning's work, and we would end up blistered and sore. Three years later and hundreds of holes behind us, we can dig close to one hundred and call in the workday with tiredness but no exhaustion, no blisters, or soreness. Of course, there will be a time when we cannot dig more than two or even 1 hole, but that is just additional evidence that the unidirectional view of time towards decay is not completely dismissible from the human perspective of it all.

This observation brings in another, which is that the passing of time in our bodies is completely dependent on the context in which the body carries on the effects of time. It is because of this that the passage of time in our bodies, the aging of our bodies, is always perceived from an

[38] Not necessarily in this text, but through the text we are leaving notes-to-future-selves of aspects that we considered interesting for future explorations when writing this text.

internal perspective of our inner experience of time, but also always in relation to the observations that we, or others, can see from the outside and based on what we have done with our bodies for the duration.

In different words, everything that happens to our bodies as we age is heavily dependent on the relations with what surrounds us. “Exposures” we might say as a firefighting epidemiologist (a term heard around Quito's critical epidemiology circles to refer to classical epidemiologists that focus on disease outbreaks). Much can also happen to our bodies depending on “inside” processes, which may not be directly impacted, albeit related to our contextual relations. That is, however, subject to another discussion. Or is it?

We could expand these reflections of human aging in the sense we have talked initially, which is the unidirectional trajectory from conception to birth to death. This unidirectional approach eventually has decay and death on its terminal end. Recalling the sayings of: living to die, that we begin to die from the day we are born, or that every loop of the sun catches you shorter of breath and one day closer to death. It is a human perception, all-too-human, as it orients us towards death and decay. But what intrigues us now is to analyze what happens when we reflect on this aging process when we take a step outside human considerations, and dive into the pass of time on life itself. Can our perceptions of aging and illness commonly associated shift when we see the impact of time beyond the human condition?

On planet earth, and perhaps even at a longer cosmical scale, the pass of time on life is not a unidirectional trajectory towards decay and death. Life, or the living, can be easily and evidently located on a circular or spiral trajectory towards life. The living ride time towards life. That is the simple but complex observation that we want to discuss based on what ourselves and others have observed. As we write when reflecting on the main lesson that chromatography gives us[39]: only life can create life for the living. When we look at the living using our intuition to locate

[39] See section 3.2 Chromatography.

ourselves, our analysis, and observations, within life itself, to see life from the inside, instead of looking at it from the deceitful god-trick maneuver that objective human science is fond of taking.

The deceit of time orienting objects in a unidirectional trajectory is easily discarded when applied to “inert” matter, or the non-living. Transformation of energy, nothing is created or destroyed. A rock is formed, as example, when the pressure and temperature fuse and aligns mineral matter in particular arrangements, time with the contextual aid of water, wind, and a crafty mason, weathers down the rock into dust, a breakdown of its matter into smaller matter that ends up as sediment on the bottom of the ocean, where it may lie until further transformation happens to it. The phosphorous atoms on that rock ended on a pasture field where microorganisms redoxes it and combined it with different atoms and electrons. It was then absorbed into a plant to create enzymes before it was chewed and digested by a cow that fixed it into a molecule on a liver cell wall to create energy. The cow was slaughtered after a lifetime of free grazing and a small boy ate the liver that contained this phosphorous atom and fixed it into his growing bone structure. Many years later, the bones turn into dust that eventually is compacted into a different type of rock.

So, the trajectory of a phosphorous atom on time is not linear if we see it from the atoms and matter that make up that rock, from rock to dust to rock again, and the countless other temporary transformations that this matter may take over time.

Let us apply an observation of the passage of time to the living, on life itself. If the stuff of life is carbon-based molecules, at least most of life as we know it, then we can say that a trajectory of life on earth can be to track the transformations of carbon or any other element as it passes from a living organism into inorganic forms and back into the living. An immediate approach that would spark the inevitable first observation that not only life is directed towards life again, but it does so with “necessary” passage through the inert, the mineral, the inorganic, the “dead.”

This is the carbon cycle, and why regenerative / organic / agroecological / blabla agriculture shows us that all we do as responsible humans is to aid in the faster transformation of carbon.

We do not “sequester” carbon from the atmosphere to the soil when we increase organic matter content, same as we do not “release” carbon to the atmosphere when we burn our once living ancestors for energy. What we are doing is altering the carbon cycle in terms that we, as humans, find difficult to comprehend, since it involves the pass of time of carbon (the atom). The carbon cycle as a hyperobject[40]. It can be fascinating and there is much to learn from tracking its trajectory on our planet beyond human interference with it, as its relations with our fundamental questions of soil, health, and the living are broad and interconnected.

The living organism with its components maintains itself living by consuming other living organisms. We are all cannibals. This being then dies as it is and gets absorbed and transformed (eaten) into what that organism uses for its physiological processes. One life gives way to another. A predatory relation, in what we see from a human perspective. But soil is the ultimate recycler for the living. And this is true even for water-based life? Sea floor compost? When an organism dies, or it is killed, its linear trajectory towards decay has reached a conclusion, an end. But life does not even notice, as 100% of its matter will eventually be used for life again. The macro-organisms that will eat it first and break down its larger components are the most obvious ones, but breaking down its smaller components into organically usable molecules is mainly done by the soil with all its transformational power from its living beings that make it up. All this reflection ends up in the soil, and that is where the reader is headed if they decide to continue with us into Part 3.

Before digging into soil, we have some more detours into theoretical realms. What will be addressed in the next sections is a review and understanding of a way of “thinking,” a school of thought, or an approach on how to understand living processes or the world in general: Vitalism. We will present vitalism by contrasting it with what historically has been its contrarian perspective. In an attempt to connect the philosophical concepts we have presented, used as departure points for discussions of what health is and how to study it, we will try a vitalist reading

[40] This is Timothy Morton’s term; one we will reference and explore further in section 2.8 Healthycology – health in in times of … hyperobjects.

of one relation that serves as an integration for adaptability, normality, autopoiesis, and the living: the interaction of organism/living being and milieu.

Let us leave here the reflections of intelligence and intuition, of life and death, with a poem.

"iQué es la muerte para el que la mira?
iQué es la muerte para el que la siente?
Pesadez ignota, incomprensible,
dolor que el egoísmo trae, para ese;
silencio, paz y nada, para este.
Sin embargo el uno siente
que su orgullo se rebela, que su mente
no soporta que tras la muerte nada quede,
que tras la muerte este la muerte.
El otro, en su paz, en su silencio,
en su majestad inconsciente siente,
nada siente, nada sabe,
porque la muerte es la muerte
y tras la muerte esta la vida
que sin la muerte solo es muerte."

What is death for the beholder? / What is death for the dying? / A weight beyond knowledge or understanding, / A pain for the self-asserting ego, for the one; / For the other, silence, peace, and nothingness. II Yet the one feels his pride in anger / And in his mind he does not accept / That beyond death nothing should arise, / And that beyond death / There should be only death. / The other, in his silence, / In his unknowing majesty feels, / He feels nothing, he knows nothing, / Because death is death / And life without death is only emptiness. II

(Maturana and Varela 1980, xi)

2.5 Vitalism and mechanism

After the previous reflections, we can hop back on our philosophical chariot and keep heading down. The path now takes us into a confrontation of two viewpoints, with their struggle as old as writing and probably older still. We would like to remind the reader that although we present this as a contrasting view of this or that, that is a consequence of our literary inabilities and the shortcomings inherent to the format of the present text. To be clear, it is not either vitalism or mechanism, as the only two sides of the coin. The coin always has a third side, and that side is a circle, so it has infinite points. But it is pertinent to lean back on our fundamental questions, ones that we already presented and departed from in the previous sections: How can we study life on our planet, ourselves included? Is there a way to understand all the intricacies of the living organism? There are as many ways, or methods, to study life as there are cultures and people on the planet.

When it comes to thinking life, we paraphrase Canguilhem's propositions in his lectures on Vitalism (Knowledge of Life Part 3, chapters 3, 4, and 5). Can we use a philosophical approach to biology? Is it possible for a biologist to dive into rethinking philosophical concepts, such as life? Can we agree that the basic question – what is life? – is already a question posed by biology to philosophy, and vice versa? In other words, the combination of biology and philosophy is not necessarily a straight one, and it can easily happen that the biologist who attempts philosophy lies into critical distress and confusion just as the philosopher who studies biology. However, Canguilhem sensibly adds, "can one reproach the philosopher who has taken up the study of biology for choosing, among the teachings he has received, the one that has best enlarged and organized his thought?" (Canguilhem 2008, 59). Thinking life (or medicine or health), is a meaningful approach for either biologist or philosopher.

We suggest that this is a task for a geographer, since there is no academic field more suited to combining diverse areas of study around a single unit of analysis, in our case life and the living. However, we recognize from the theoretical frameworks that guide us, that thinking life is a task that can hardly be completed or totalized, even if that is our aim or goal. A task commanded by our will, to alleviate our intellectual and poetical curiosities, it is also an inherently impossible task. And we must not be disheartened by this realization, but rather encouraged to continue in search of an answer to the questions of life, since it will not matter how many authors have attempted it, there is always room for one more in this unending spiral of knowledge.

Before we dive into further discussion of the topic of milieu and its meaning and relation to the living, be it in the living body of a bipedal mammal or in the dynamics of a life-giving soil, we need to take the path into a term that is apparently out of date in contemporary biological philosophy.

The term, vitalism, corresponds to a way of thinking that is not new at all, but we suggest it can be reworked and used in contemporary geography and medical theory to deal with the challenges posed by the questions we proposed. Despite the relatively scarce use of the term as it is, vitalism is definitely vital in contemporary critical theory, philosophy, and geography. Broadly, vitalism is thriving within all theoretical and conceptual frameworks that have a close relation to its classical concept that insists that living beings cannot be explained through reductive, mechanistic theories of matter, but must instead be understood through their processual relations.

To describe how we understand this concept we will base most of our discussion on the works of Canguilhem and Bergson, but we can argue that many authors and traditions that deal with questions of life and health have an underlying basis in the philosophy broadly categorized here as vitalism. Much of the contemporary work on vitalism in anglophone academia is due to the emergence of currents such as "new materialism," and, more broadly, of a move towards processual and non-representational approaches to theory and research.

In a comprehensive review of vitalism in classic and contemporary philosophy, Monica Greco writes that if "in its classical versions, vitalism expresses a concern with explaining the specificity of biological life, in this other context vitalism as a concept is addressed to reality as a whole, eliding the categorical difference between animate and inanimate, living and non-living entities." (Greco 2021, 48)

Canguilhem distinguishes roughly two types of the vitalist thought. The first one can be the earlier holistic organicism that focuses mostly on the self-sameness of the totality of life -German Lebenphilosophie, including and perhaps spawning from Bergson. The second one as a later interactive vitalism, linked to the work of Jakob von Uexküll and Kurt Goldstein, which focuses on the crucial relation of mutual exchange between the living center and its milieu (Bielik-Robson 2018, 5). Jakob von Uexküll, for example, presents the concept of Umwelt, in which he argues that every organism experiences the world in a unique and subjective way, based on its sensory capabilities and the specific interactions it has with its environment. He called this subjective world the "Umwelt" of the organism, and he believed that understanding an organism's Umwelt was essential to understanding its behavior and cognition. (Von Uexküll 1934)

For Canguilhem, “vitalism is the expression of the confidence the living being has in life, of the self- identity of life within the living human being conscious of living” (Canguilhem 2008, 62). As expected, there are authors in the early-mid 20th century that could be seen as vitalists that do not fit in this careful classification. Hannah Arendt is one example, in particular as her concept of natality[41]. Another one is Ortega y Gasset, who in the early 20th century faced with two basic alternatives: acceptance of devitalized rationalism; or an explicitly anti-rational vitalism. Ortega chose neither, and his development of the “razón vital” vital reason, “his attempt to find a balance between what he considered to be the hyper-rationalism of the nineteenth century and the anti-rationalism of many fin-de-siècle thinkers.” (Shields 2007, 1).

“New” vitalism(s)

The enthusiasm to rethink ontological possibilities is highly connected to the classical idea of vitalism and has been carried to contemporary critical theory by many authors, but perhaps the most relevant for us the work of Deleuze and Guattari, Karen Barad, Donna Haraway, Annemarie Mol, Eduardo Kohn, and even of Whitehead and Von Uexkull. (Deleuze 1990; Deleuze and Guattari 1987; Barad 2007; Haraway 2009; 2016; 1997; Mol 2002; Kohn 2013; Whitehead 2014; Von Uexküll 1934).

In *The body multiple; ontology in medical practice*, Annemarie Mol (2002) explores a single disease in one hospital, and delivers her main argument by claiming there is no such thing as a singular disease, or body, or any kind of medical object. Mol’s ethnography of disease blurs the idea that there is such a thing (as disease) but at the same time acknowledging that there is

[41] A quote from Hannah Arendt, in the book *The Human Condition* (1998) as cited in (Bielik-Robson 2018, 84). “If without action and speech, without the articulation of natality, we would be doomed to swing forever in the ever-recurring cycle of becoming, then without the faculty to undo what we have done and to control at least partially the processes we have let loose, we would be victims of an automatic necessity bearing all the marks of the inexorable laws which, according to the natural sciences before our time, were supposed to constitute the outstanding characteristic of natural processes . . . to mortal beings this natural fatality, though it swings in itself and may be eternal, can only spell doom.”

something we all try to convey when we use that or any of the other terms (illness, sickness, pathology, infirmity, so on). She is witnessing ‘reality’ on this hospital and its inhabitants, like Eduardo Kohn, in his book “How Forests Think: Towards and Anthropology beyond the human” (2013) is witnessing the ‘reality’ of selves, forms and forces through semiotic relationships in the larger ‘we’: himself, the Runa, the Forest and its ‘ecology of beings’ (Latour 2014).

Recognizing there is no single way to think/talk/act on ‘disease’ or body’ opens up a way to hybridize and harness diversity across modes of existence. The previous sentence paraphrases Mol, Kohn and Latour, and presents how a form of vitalism in contemporary approaches has been applied beyond “life” to a wider sense of “reality” as a whole. By presenting a “patchwork image of atherosclerosis of the leg arteries: a single disease that in practice appears to be more than one – without being fragmented into many. Thus, a body may be multiple without shifting into pluralism”. (Mol 2002, 151). One of these ethnographies is told within the different ‘enactments’ that constitute a disease, the other with the different forms and ‘thoughts of forest beings, but both meet in the “search for a better way to attend to our relations to that which lies beyond the human, especially that part of the world beyond the human that is alive, forces us to make ontological claims—claims, that is, about the nature of reality.” (Kohn 2013, 9).

There will be more discussion of Kohn’s work when we discuss the relation of the living and its milieu, but for now we are presenting them as examples of contemporary academic work that knock on the door of vitalism for rethinking relationality within our organism and with the environment (milieu) at large, blurring their distinctions into a combination that makes room for creative and critical work.

We find ourselves agreeing with Mónica Greco’s account of new vitalisms, or the so-called neo-vitalist turn (Gandy and Jasper 2017), when she writes that this turn is “one that would supersede the ‘discursive’ while encompassing the ‘affective’ and the ‘ontological’ (turns) – the latest in a series of turns to claim the theoretical cutting edge in disciplines ranging from geography to sociology, to art and literary criticism.” (Greco 2021, 49). A turn is perhaps something static that wants to move; at the same time, it may be something that is moving that wants to stop. We, as immigrants to the English language, read the word 'turn' as a verb (move, change, start, shape) more than as a noun (an act of moving, an opportunity or obligation to do). There is one author that subtly avoids calling it a turn and borrows the term of an ongoing 'ontological program' in anthropology, which "is nothing more than a change in the disciplinary-language game" (Viveiros de Castro 2015, 16; Reyes-Foster 2016; Fischer 2014).

In words of Viveiros de Castro, the turn is a "deformation-translation-variation of certain conceptual certainties of the analyst so as to make sense, I mean, make real (which does not mean make actual) the certainties or, for that matter, the perplexities of the other." (Viveiros de Castro 2015, 13). He pursues this idea of "making room" for the "Other," borrowing from Strathern and Deleuze, towards an anthropology of the "good enough description." To phrase it in another of his statements, his work is re-shaping the values behind what 'we' (a planetary/cosmical and beyond the human we) value as prosperity and life: "There is no better than enough" (Viveiros de Castro 2013, 37).

Let us take another short detour here into what could also be labelled as a new vitalism to recall what Bruno Latour calls the *constitution* of the moderns. Latour can be regarded as one of the representative authors within the ontological turn in the social sciences. In one of his earlier works, Latour presents that modernity conducts a set of practices that are clearly separated: purification and translation. Purification work includes distinction, separation, contradiction, tension, incommensurability, so on (Latour and Porter 1993, 58); we can therefore understand 'the whole' by looking at – separating, classifying, ordering – the parts. 'Translation,' or mediation, on the other hand involves a messy and asymmetrical interconnection where everything is related to everything. We can witness both practices happening at the same time, but the strict separation between the two, as a separate set of practices, has been a characteristic of modernity. That clear separation, one that has allowed the power and invincibility of the moderns (Latour and Porter 1993, 37), a power that is now in crisis. This distinction is not so different from what Bergson contrasts intelligence vs. intuition; or what some call mechanism vs. vitalism.

This is what comprises Latour's modern 'Constitution': two alternating sources of power between a pure natural force and a political force, where the domains of nature and society are absolutely distinct and separate, and with a (crossed out) ~~God~~ totally impotent but ever-present judge to limit the two forces and be mediator of last resort. Latour goes on to say that if this is how the modern constitution is outlined, "modernity has nothing to do with the invention of humanism, with the emergence of the sciences, with the secularization of society, or with the mechanization of the world. Its originality and its strength come from the conjoined production of these three pairings [natural and political force, nature and society, and a ~~God~~ that cannot act but can judge] of transcendence and immanence." Modernity can therefore mobilize Nature while claiming that it is beyond us; objectify the social while recognizing that we construct society; and feel the experience of God but remove any agency from it. (Latour and Porter 1993, 34). Later, we will follow Canguilhem and partially disagree with Latour on this, especially when he claims that this "constitution" is exclusive to modernity, as we will see that the alternating forces (i.e., vitalism and mechanism) oscillate historically with claims of hegemony from one side and rebellious contestations from the other. Furthermore, as we learned from Varela and Maturana, we see that it is not enough to label something mechanistic to be contained by a mechanistic perspective of life.

Vitalism as a theoretical approach can also be seen in many other areas, although most of our examples at this point will dwell on medicine, biology, and health. In other sections we will also investigate vitalism in connection to other themes, most of these just glanced over or tangentially addressed. These include Bergson's notion of duration (*Creative Evolution*, *Matter and Memory*, *History of the Idea of Time*), in which things change, but change is not external to the object nor imposed upon it. There is also Alfred North Whitehead's concept of "concrescence," somehow not unrelated to "becoming." "When we analyze the novel thing we find nothing but the concrescence – " 'Concrescence' is the name for the process in which the universe of many things acquires an individual unity in a determinate relegation of each item of the 'many' to its subordination in the constitution of the novel 'one.'" (Whitehead 2014, chap. X, Process, 211).

In the opening chapter of a compilation of “new vitalisms”, editors Mariam Fraser, Sarah Kember, and Celia Lury (2006), point out a few key agreements or coincidences across what can be considered contemporary vitalist thought. One basic agreement is about process. “Process, in other words, is characterized by a radical relationality: the (social and natural) world is understood in terms of constantly shifting relations between open-ended objects. This is not to suggest that there are relations between pre-existing entities or objects. Instead, objects, subjects, concepts are composed of nothing more or less than relations, reciprocal enfoldings gathered in temporary and contingent unities. Furthermore, a relation cannot exist in isolation, all entities can be understood in relation to one another.” (Fraser, Kember, and Lury 2006, 13–14)

It is not only this explicitly relational ontology that defines vitalism, but other qualities from those who may or may not adhere to the label. For example, we see an explicit vitalist thought in relational geographies that state having “an epistemological stance open to surprise and employing an anti-essentialist causality that builds explanation through multiple intertwined causal structures, actants, subjects, knowledge and exercises of power” (Elwood, Lawson, and Sheppard 2016). This is like how Canguilhem, by following Bergson, sees élan vital as a transgressive force investing in more and more freedom of responses of a ‘living subjectivity’ to the surrounding world. This evidences that adhering to a “vitalist thought,” whatever it may mean to different people, may be just another way of not adhering to any set camp within academia. As another critical race theorist, Donna Jones, presents it, “Bergson’s critique was aimed just as much against mechanism, the idea that sufficient computational power made the future predictable from given, initial conditions, as it was against finalism or teleology, which rendered process as fully determinate and predictable as mechanism.” (D. Jones 2010, 77). Perhaps this corresponds with “Bergsonism” or even “Vitalism” being close to a derogatory insult by many through the decades since it implies an explicit denial to choose from any of the hegemonic discourses of the times.

We propose, as Canguilhem does, that vitalism is not necessarily a strict set of arguments, dogmas, or preconceptions; although being a way of thinking it does have some of these consensual bases across those who adhere to it. It is through this discussion of vitalism and mechanism, as philosophical tools to think about life and the living, that we engage in a more in-depth analysis of some of the key theoretical foundations of the hegemonic medical model as they pertain to our initial and framing questions. In the process of clearing and delineating this wide concept, we aspire that it shows how it has guided our methods to carry out the work of understanding health as a concept, within soils and organisms, and the relations with which they are embedded.

Canguilhem's vitalism

The work of Canguilhem on this topic is spread through his work, but we focus here on the writings in part 3 of his book *Knowledge of Life*. Also, we refer to Stuart Elden's review of Canguilhem (2019). Besides Bergson's book *Creative Evolution*, Canguilhem's influences from vitalism are broad and old, and we cannot ascertain that we cover them all, but some of the old ones are Spinoza, Leibniz, Paracelsus, Aristotle.

Canguilhem's attempts to bring back the "vitality of vitalism" shows us a very interesting review of the history of biological theory, always located within confrontative opposites and it oscillates and divides together with history. It is not in doubt that, at least when it comes to biomedical biology from the 19th century to our days, the large body of work of those under a mechanistic thought has been on the hegemonic side of this confrontation. Lynn Margulis describes the confrontation of these epistemologies and narrates the hegemony of mechanistic thought. "Finally, the last outpost of animism –living organisms– yielded to the philosophy of mechanism. Motion needed not imply any inner consciousness; the program could have been 'built in' by a creator." (Margulis and Sagan 2000, 5). Before this quote there is a great synthesis of monotheist hegemony as the prelude to mechanist epistemology. She continues with how inventors began representing the cosmos and living things as "lifeless mechanisms, subtle concealed springs, tiny unseen pulleys, levers, cogs, and gears. Comparing flowing blood to a hydraulic system, the heart to a pump, English physician William Harvey (1578-1647) discovered circulation of the blood." (Margulis and Sagan 2000, 6). Let us add the following to that quote: French physiologist Claude Bernard (1813-1878) coined the biomedical dogma of a separated inner milieu by experimenting on one molecule (glucose) as it moved into and from one organ (liver) of several individuals of one species (dogs).[42]

However, Canguilhem warns us that this confrontation is not uniquely situated in a match of mechanism vs. vitalism, but that it depends on the arena. “Mechanism and Vitalism confront one another on the problem of structures and functions; Discontinuity and Continuity on the problem of the succession of forms; Preformation and Epigenesis on the problem of the development of a being; Atomicity and Totality on the problem of individuality.” (Canguilhem 2008, 61). The key to the vitality of vitalism, as Greco sees it (Greco 2006), relates as much to its ontological as its epistemological role. Vitalism as a mode of thought on the living is to focus on the object of life itself and where it may fail to offer a valid representation of life, vitalism serves as ‘a valid representative’ – a symptom of the specificity of life. As such, vitalism is consistent with a non-essentialist ontology. “For Canguilhem, though a vitalist himself, vitalism as a general, positive doctrine is strictly speaking erroneous. There is no generalized life force as such (nor is mechanism straightforwardly ‘false’).” (Osborne 2016, 187)

The confrontation of mechanism against vitalism lies on a matter of historical significance of those who have adopted the term and those who have been labeled into one or another side of the debate. Vitalism has been used as a “label for so many extravagances that, at a moment when the practice of science has imposed a style of research and, so to speak, a code and a deontology of scientific life, vitalism carries a pejorative value even for those biologists least inclined to align their object with that of physicists and chemists. There are few biologists who, classified as vitalists by their critics, willingly accept this label (…) as a consequence of the signification it acquired in the eighteenth century, the term vitalism is appropriate for any biology careful to maintain its independence from the annexationist ambitions of the sciences of matter.” (Canguilhem 2008, 60)

Bergson’s work is commonly referenced as a key work for vitalism, and criticism of vitalism has also been labeled with the usually pejorative term of Bergsonism, but the lineage of criticisms to

[42] More on this in the section 2.6 Milieu.

mechanism comes from Hippocrates and Aristotle to Kurt Goldstein (Goldstein 2000) and prominent physiologists such as Jean-Baptiste Lamarck, Xavier Bichat, even Claude Bernard. Canguilhem goes further to distinguish vitalism from mechanism on a more profound level, placing vitalism as the "biology of physicians skeptical of the constraining power of remedies. In pathology, the Hippocratic theory of the *natura medicatrix* accords greater importance to the organism's reaction and defense than to the morbid cause. The art of prognosis prevails over that of diagnosis, on which it depends. It is as important to predict the course of a disease as it is to determine its cause. Therapeutics consists as much in prudence as in audacity, for the first among doctors is nature. Thus, vitalism and naturalism are indissociable. Medical vitalism is the expression of a distrust, shall we say an instinctive one of the powers of technique over life. There is an analogy here with the Aristotelian opposition between natural and violent movement. Vitalism is the expression of the confidence the living being has in life, of the self-identity of life within the living human being conscious of living." (Canguilhem 2008, 62).

If we follow Bergson's approach to life, it is fully dialectical and has a clear analogy to Marxist dialectics, in the sense that they both provide the philosophical arguments to challenge the violence of mechanism (Geroulanos 2015; Harvey 1996). The inherent dialectical nature of life (the object of study) and the sciences of life "explains one of the characteristics that mechanist biologists and rationalist philosophers criticize in vitalism: its nebulousness, its vagueness. If vitalism is above all an exigency, it is normal that it would have some trouble formulating itself in terms of determinations." (Canguilhem 2008, 62)

Mechanism has a telling etymology, and Canguilhem uses it as a creative argument. From the Greek *mēkhanē*, whose meaning, *engine*, contains two senses: that of trick or "ruse," on the one hand, and that of machine, on the other. "Canguilhem uses *engin*; the OED confirms the applicability in English of the double meaning, indeed places the interpretation of engine (or "engin") as "genius," "cunning," "trickery," or "evil machination" before its interpretation as machine." (Canguilhem 2008, n. 3 translator). Canguilhem claims that if a mechanism is a ruse, it cannot create anything, and there lies its merit. It can use the ingenuity of this ruse or technique to understand facts already created. "Thus mechanism, as a scientific method and as a philosophy, is the implicit postulate of all usage of machines." (Canguilhem 2008, 63). He suggests that vitalism is not a method to make sense out of life but a demand or an exigency. Using the work of Emanuel Rádl, he proposes that vitalism is more a morality than a theory. (Elden 2019, 37). "Humans either sees himself in nature and nature in himself. Or else, he holds himself in front of nature as before a foreign, indefinable object." (Canguilhem 2008, 63). The former would coincide with a vitalist, and the latter with a mechanist. The vitalist does not consider natural phenomena, such as life, as strange or foreign, but "finds life, soul, and meaning in them, completely naturally." (Canguilhem 2008, 63).

We have mentioned before, that even though there claims of *new vitalism*s, and Bergson is commonly associated with classical vitalism, it is a very old perspective. "Plato, Aristotle, Galen, all the men of the Middle Ages, and a large number of the men of the Renaissance were, in this sense, vitalists. They considered the universe to be an organism, which is to say, a harmonious system regulated according to both laws and ends. They conceived of themselves as an organized part of the universe, a sort of cell in the universe-organism, and all cells were unified by an internal sympathy such that the destiny of the organ-part seemed naturally to have to do with the movements of the heavens." And subsequently, he adds that a vitalist is someone "who is led to meditate on the problems of life more by the contemplation of an egg than by the handling of a winch or an iron bellows." (Canguilhem 2008, 64).

Finding vitalist thought through European antiquity, and also in non-European cultures past and present, is another aspect that explains the resistance of enlightenment-based European philosophy and science towards vitalism as a sort of primitive or antiquated philosophy that does not agree with a progressive scientific reason. Perhaps connected to this aspect, we see that vitalism seems eager to present itself as a sort of return to antiquity. "The vitalism of the Renaissance is a return to Plato against an overly rationalized Aristotle. The vitalism of Jan Baptist van Helmont, Georg Ernst Stahl, and Paul-Joseph Barthez is, as has been said, a return, beyond Descartes, to the Aristotle of De anima." (Canguilhem 2008, 66). Canguilhem poses these questions and asks about the meaning of this return to antiquity. "Is it a revalorization of concepts that are chronologically older and consequently more worn out, or a nostalgia for intuitions ontologically more original and closer to their object?” (Canguilhem 2008, 66).

This brings back the idea presented initially of the dialectic historical oscillation between mechanism and vitalism. “Was Aristotle's vitalism not already a reaction against Democritus's mechanism, as Plato's finalism in the Phaedo was a reaction against Anaxagoras's mechanism?” (Canguilhem 2008, 67). Beyond this movement of thought on life and the living, we need to acknowledge that in many contemporary reactions against mechanism there is a sort of naïveté, a romantic vision of a pretechnological society. In parallel, there is also a naïve vision of an inherent superiority of the promises of a super mechanized and technology-based society that grounds retaliatory thought against vitalism.

Canguilhem poses some interesting examples of scientists that have oscillated through these apparently irreconcilable perspectives in their own work. One of his examples is Caspar Friedrich Wolff (1733-94), whose adherence to “vitalist conceptions did not prevent him from truly founding modern embryology, thanks to his capable and precise microscope observations, introducing history and dynamics into the explanation of the successive moments in the egg's development.”. At many times in history, “to be a vitalist was not necessarily to slow down the progress of scientific research.” (Canguilhem 2008, 67)

Vitalism is argued as a philosophy that trusts on the power of life to be created, or if you want, on the power of a totalizing energy that creates life. Beyond this, it is also a stand against the reducing of life and the living from a nature broken down into mechanisms, mechanisms that arranged by human will continuously try to overcome the obstacles placed by this nature. Mechanism distrusts nature and continually looks for engines to overcome it, and vitalism trusts in the healing power of nature. An interesting paradox that this latter one is basically the

Hippocratic maxim (*vis medicatrix naturae*)[43], but trained doctors in modern medicine around the world swear to the Hippocratic oath while being actively trained against his maxim.

The difference between a machine and an organism lies in that the latter can re-create itself—autopoiesis. When autopoiesis stops, life dies. But that does not tell us much about how autopoiesis (life) starts. If mechanization is the way to explain the smallest autopoietic system, the cell, then it also needs a machinist, and the debate for a machinist for the living machine is still open. Gabriel Tarde calls the founders of cell theory "Newton's true heirs." He goes on by denouncing their mechanistic conception on the living by placing them in confronting opposition to their exterior environment. "In the same way they have broken apart the unity of the living body, they have resolved it into a prodigious number of elementary organisms, isolated and egoistic, eager (*avides*) to develop themselves at the expense of the exterior, where the exterior includes their neighbouring brother cells as well as the inorganic particles of air, water, and all other substances." (Tarde and Lorenc 2012, 6).

[43] Vis medicatrix naturae (literally "the healing power of nature", and also known as natura medica) is the Latin rendering of the Greek Νόσων φύσεις ἰητροί ("Nature is the physician(s) of diseases"), a phrase attributed to Hippocrates. The phrase sums up one of the guiding principles of Hippocratic medicine, which is that organisms left alone can often heal themselves.

Encounter 5 – Sunfo, Clinopodium nubigenum

We have been looking for sunfo since we know of its existence, a direct or clear date is hard to pinpoint, let's just say at least 15 years. We know it is an elusive and tiny plant of the páramos, at least over 3,500masl. We know it grows lying down on the ground to avoid the chilling winds and sleet at this high altitude. We also know it's smell, because we've had its tea many times, especially when visiting people up in the mountains, frequently of Kichwa nationality. It is slightly aromatic and earthy, with a hint of sweetness, and well known for its properties as an altitude sickness medicine.

Many years later, it was July 7th, 2019, we find ourselves on a birdwatching trip with our father, we group with a bus full of people towards Pintag, and then up the mountain range towards the Antisana volcano and the Mica Lake. The main goal of the group was to go see the condors, a goal that was thoroughly accomplished as we saw many in very close range, for some in the group it was a first encounter with these magnificent creatures. Since the trip was part of a local tourism venture, they were taking us to many stations along the way to see a diversity of handicrafts, foods, and locations. Once inside the Antisana reserve, the bus stopped to see a group of riders on horses. Both horses and humans where fully attired in chagra style equipment, as a chance for a photoshoot with the city tourists. Being part of the chagra culture myself, but from the neighboring valley of Machachi - with a latent rivalry of who claims to be the more "authentic" chagras - we weren't impressed and had no interest in a photo. We stayed close to the bus rolling myself some tabaco and taking the position as an outsider to the scene, in a way only tobacco smokers can understand.

One of the many gifts of tabaco are the moments of solitude when in a crowd and offers the possibility for actual and meaningful encounters and connections to outsiders, smokers or not.

An older lady, in her late 60's, approached her companion, a younger woman of about 40, both were also not interested in the horse show. She took something from her pocket and was showing it as a sort of discovered and secret treasure. We could only overhear the words "estaba ahí nomás al ladito de donde se paró el bus" with a tone of excitement. We had to ask, as by now we were sure it was a plant they were talking about. We approached slowly and asked in the humblest, polite, and even shy way we could invoke: "disculpe señora, ¿qué encontró?" She looked at me and opened her eyes wide while showing me the treasure with both hands: "¡Sunfo!" She showed me the place, right next to the back tire of the bus on the curbside. She had a handful already, so we just took a few leafed branches and placed them in a bag to make some tea later. We weren't in full botanical research mode then, so we didn't bother with any photos or careful sampling, we were just happy to have found a person that had keen eyes for the right herb of the place.

Plant-people show up even among urban birdwatching aficionados.

Two years later, and now we have intensely look for sunfo every time we think we are in its milieu, but to no success. Forward to a Sunday in January 2021, and we go to the same lake with family for a day trip. We gather observations of plants, soil, and territory, take samples and careful photographs all along the way, as now we are in full botanical research mode. We manage to convince the crew to stop for a snack at this turn on the road in the páramo with nothing interesting apparently visible. As they prepare sandwiches we stroll along the road, again with my tabaco, asking for a re-encounter. Of course, we couldn't remember the exact place that the bus had stopped but it was close. And there it was, lurking over the curbside, camouflaged across the páramo sponge, we were sure we had found sunfo again when we picked a branch and perceived its soil scent. We left some tobacco in the place we picked it and was sure in our heart that the both of us have now been acquainted. Sure enough, two weeks later we hike up the Ilinizas, where we found more sunfo that we have ever found in our life. It was everywhere we looked, so we only took one bag to dry and include it in our herbal pharmacy. Up to our last journal update, we have identified at least 20 spots in the nearby páramos where we can go for sunfo if called for.

Image 3. iNaturalist. Observation of Clinopodium nubigenum from Oyacachi, Ecuador. Observed on 1/22/2022. Exported from https://www.inaturalist.org/observations/105428860 on 7/6/2023.

Discreet and shy
Close to my heart down below
Your smell of soil and malt
Outer space is your geography
Carry me lightly over your smallness
Stay locked in time and space
Cause yours is the love and the gift
Of the mountains sweet.

2.6 Milieu

Much has been already discussed about the idea of *milieu* in previous sections of Part 2, but the importance of the term in our attempt to answer the fundamental question of what is health, and how to understand It, merits a particular section where we will describe its relevance further. As we have done with other concepts – adaptability, normality, intuition, vitalism – the best approach we can find is to analyze it in relation to other concepts while constantly returning to the fundamental questions that guide the project. We adhere to the French term *milieu* instead of *environment* or *nature* primarily to differentiate our vision of its meaning from those other more commonly used or understood terms. Our use of the term is also relevant since our main treatment of the term comes from Canguilhem's reflections upon it.

The separation of organism and milieu recalls the previous discussion on experimentation as the method for understanding the living body[44]. The method – the experimental method for medicine – at least as outlined by Bernard, relies on understanding that there is an internal environment within the living organism that is complex and different from an external, or cosmic, milieu. This internal environment is unique to living beings; it is absent for "inert" bodies. Moreover, according to Bernard, understanding how the different "parts"[45] (organs, tissues) of the organism relate to the internal milieu (comprised of blood and other "fluids"), is the motive why physiology is the "basic biological science" and why it can use the same laws, instruments, and practices that physicists and chemists use to understand the external milieu (Bernard 1949, 65). However, the "difficulty" arises from the fact that this internal milieu is not as easily altered (i.e. experimented) without causing irreversible harm to the organism[46] –that is of course why animal experimentation is so important to modern biological sciences, where vivisecting animals with the greater goal of healing humanity seemed like a good tradeoff for such physiologists.

It is clear to us that such separation of organism and milieu is a product of Bernard's (and plenty of others in the positivist 'scientific' tradition) necessity to prove that biology could be grounded in experimentation. The task of overcoming the organism/environment divide parallels the intentions of Kohn and Haraway, to mention just those two authors, to think *beyond* the human. "Why ask anthropology [medical epistemology in our case] to look beyond the human? … It can tell us about how that which lies "beyond" the human also sustains us and makes us the beings we are and those we might become" (Kohn 2013, 221, with bracketed note added).

If we are to recognize that there is no such contraposition between an internal and external environment, we can recognize that living beings are not in-their-environment, but that organisms and inert bodies are constantly constructing the environment of which they are a part of. The milieu of the living and nonliving not as a container of beings, but as an open-ended spectrum that scales up and down from intra cellular space of our hepatocytes to the

[44] Chapters 2.1, 2.2, and 2.4.
[45] A reference to this method as a *mechanistic* doctrine, see Chapter 2.5 Vitalism and mechanism.
[46] Recall section 2.3 Particularities of the living organism, fourth particularity: the irreversibility of vital phenomena.

gravitational pull of the Moon, and beyond in both directions. To use Kohn's and Haraway's terms: a milieu 'that grows' and 'composts.'

We envision this open-ended milieu drawing from Donna Haraway's narration of *Terrapolis* as an "n-dimensional niche space" of multiple companion species composted together in a transformative brew (Haraway 2016) [47]. Terrapolis can also be worded as Pachamama, to use the Andean term referring to the planetary beyond "the natural." Mother-Earth (literal translation from Kichwa of Pacha-Mama) as a fertile womb where life and death take place can radically affect our view of human health. There are two definitions of *pacha* in Kichwa: 1. World, space, nature, ecosystem; and 2. Epoch, time.[48]. If we dare summarize those two definitions: time and space, reality. This understanding, at least to us, gives a larger meaning to what Pachamama, the mother of pacha, can be beyond the sometimes-trivial expression of Mother-Earth. Perhaps we could leave pacha as a good enough definition of milieu.

The milieu where life takes place, this Pachamama, or Terrapolis, is presented as an alternative to the continuation of the anthropocentric appropriation of the planet. It refers to an emancipatory project, where knowings are 'composted' together beyond all-too-human hegemonies and totalizing intentions. Knowing then is on par with belonging to the planet and situating our faulty and partial understandings of the world and its beings. That is how locating our knowledge (of medicine) within Terrapolis can "inoculate" us from the modes of sociocentrism and humanist exceptionalism. This Terrapolis of beings composts everything together into "the stuff of life", borrowing from Lynn Margulis (Margulis and Sagan 2000, 24),

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[47] "Terrapolis is a fictional integral equation, a speculative fabulation.
Terrapolis is n-dimensional niche space for multispecies becoming-with.
Terrapolis is open, worldly, indeterminate, and polytemporal.
Terrapolis is a chimera of materials, languages, histories.
Terrapolis is for companion species, cum panis, with bread, at table together—not "posthuman" but "com-post."
Terrapolis is in place; Terrapolis makes space for unexpected companions.
Terrapolis is an equation for guman, for humus, for soil, for ongoing risky infection, for epidemics of promising trouble, for permaculture." (Haraway 2016, 11)

[48] Translated from Spanish by the author. Translation from Kichwa to Spanish: 1. mundo, espacio, naturaleza; ecosistema; and 2. época, tiempo.(Chango and Potosí 2009).

where we can find plenty examples of organic “living” cells producing inorganic “inert” minerals. Such a view resists the dominant biomedical dogma that constructed the organisms’ “inner milieu” in contrast and conflict with an “outer” environment, or Nature.

Organisms are constantly constructing their milieu. We detail some examples of this in Part 3, where some interesting ones we have observed being the change that *introduced* species such as the eucalyptus or pine trees have brought to the Andes. Eucalyptus trees have dried swamps and wetlands to the point that they are the main species found in places they were planted; and pine trees have managed to change the soil structures and microbiological flora, fauna and funga on the soils they inhabit.

In this discussion of “organisms,” where are humans? The capacity of humans to influence their milieu is an easily observable fact. From the manufacture of clothing to social organization, humans have managed to *adapt* themselves within a wide diversity of contexts. But perhaps the key ability of humans is their capacity to shape their environment. How this construction of “human environments” changes humans as living beings is a discussion too large for the present moment. Agriculture, in general, stands as a particular and keystone activity in shaping the context of the reality of humans. Whether humans use this capacity to construct their milieu in ways that allow the continued existence of abundant life on the planet, or to homogenize and reduce expressions of life (human included) remains to be seen.

Let us recall the central questions that brought us to this point: what is health? What is life? How can we understand and study health and the living? Here is where we can draw a direct connection between agricultural models and medical models as activities or tools used by humanity to shape their environments and their bodies. Agricultural and medical practice entail a relationship with multiple other forms of life, as well as with *inorganic* elements or objects. Such practices are not only determined by the relation of humans with other beings/things, but also these practices deeply influence the fate of such beings/things and their form of existing within the planetary milieu. If there is one characteristic of many agricultural and medical systems, certainly but not exclusively in the dominant one, is that they are centered on the human, anthropocentric. Can there be a non-anthropocentric medical or agricultural model? We claim, as Kohn does for his ‘anthropology beyond the human,’ that such knowledge will always be about the human, but the key distinction is in the method—or where we aim our sight. Then, can we set our gaze away from the organism/environment divide? We will go on as if there is such a way of knowing, one where life is embedded in the continuous transformation of energy and matter happening on Earth.

“Life—both locally, as animal, plant, and microbe bodies, and globally, as the biosphere-is a most intricate material phenomenon. Life shows the usual chemical and physical properties of matter, but with a twist. Beach sand is usually silicon dioxide. So are the innards of a mainframe computer-but a computer is not a pile of sand. Life is distinguished not by its chemical constituents but by the behavior of its chemicals. The question "What is life?" is thus a linguistic trap. To answer according to the rules of grammar, we must supply a noun, a thing. But life on Earth is more like a verb. It repairs, maintains, re-creates, and outdoes itself.” (Margulis and Sagan 2000, 14).

Physiology beyond-the-human – livers, glucose, and milieu construction

Let us expand by using an example or personal image of a specific physiological process that happens inside a body, but it also happens in conjunction with the world beyond us and other tissues or processes, beyond humans. How is the liver and its role of providing energy to the organism, by its glycogenic and glycolytic functions, related to the internal milieu (blood, hormones, circulation, breathing) as it is to an external milieu of eating, fasting, resting, and struggling. Dare we call this a physiology beyond-the-human?

Returning to Bernard’s experimental method, his consideration of an inner milieu as the setting for physiology (and pathology), led him to conduct his most famous investigations on the liver and glucose. Bernard realized that animals had glucose in their blood even if they did not eat. A dog fed on carbohydrate food for seven days was killed during digestion, and Bernard was able to show that the blood of the hepatic veins leaving the liver contained a large amount of glucose. The same thing would happen to a dog fed only on meat, this time with no glucose in the intestines (Bernard 1949, 163–64). This seemed to be experimental proof that glucose was not only coming from diet but also produced within the body. Those experiments, among many others, became the grounds for Bernard's "discovery of the glycogenic function of the liver" as a physiological fact that is independent of the nature of alimentation. We can follow his argument, but it seems like a leap that he would consider that such a process is "independent" of extra-corporeal processes. Let us follow the metabolism of glucose and the related physiology of the liver within the living (mammalian) body to try and understand the process that Bernard discovered.

When we eat breakfast and then sit in the bus for the daily commute, the body is at rest and fed, glucose supply is abundant, and there is not a considerable demand for energy expenditure. Hepatocytes in the liver, stimulated by a high ratio of insulin/glucagon coming from the pancreatic ß-cells, take the circulating glucose and store it as glycogen (glycogenesis). Such a process lowers blood glucose concentration into "normal" physiologic range close to 100 mg/dL. This glycogen was then generated by glucose that came into the body by the plants and animals, possibly fungus, consumed, and it was a process that involved hands, lips, saliva, esophagus, stomach, intestines, pancreas, veins and arteries, heart, blood, hundreds of enzymes, neurotransmitters, brain… in general, the entirety of the organism.

Dozing off by the effects of the alkaline tide after digestion, we get to the workplace, where we begin to use a wheelbarrow to spread a 6ft tall hill of mulch around the trees and guilds of an urban garden. After a few hours, glucose levels begin to drop due to the increased demands of energy from the working muscles. The ratio insulin/glucagon gets inversed; epinephrine is also secreted by our adrenal glands as a result of the exercise. This increases blood flow to the liver and the hepatocytes begin to generate glucose by breaking up the glycogen; the cascade of glycolysis takes place, also filled with enzymes and feedback loops involving the entire organism. After the workday, we harvest artichokes and bring them back to the kitchen to prepare a meal and replenish the glycogen stores in the liver. Glycogenesis again.

Bernard – as the positivist physiologist / physician – may argue that all the process happened "inside," within our internal milieu. However, we can see that the process involved many other living organisms that gave us glucose (and amino acids for the enzymes) in the first place. It also involved a bus, a road, a shovel, and a mountain of woodchips. The desire for glucose, among other things of course, allowed the liver to carry out a particular physiologic process that in turn permitted us to continue transforming an abandoned parking lot into a food forest. Needless to say, the same process also changed the life of the artichokes in a very impactful way. Desire and possession, using Gabriel Tarde's terms, shape our liver, the artichokes, the parking lot, the city, and us (whatever that is).

The relation of the liver cells with the artichoke is reciprocal, they give us glucose in the summer, the liver gives us energy to plant artichokes in the fall and compost during spring. The desire and properties of an organism are all other organisms, alive or inert.

"Each mass, each molecule of the solar system, for example, has for its physical and mechanical property not words like extension, mobility and so on, but all the other masses, all the other molecules; that each atom of a molecule has for its chemical property, not atomicities or affinities, but all the other atoms of the same molecule; that each cell of an organism has for its biological property, not irritability, contractibility, innervation, and so on, but all the other cells of the same organism, and in particular, of the same organ." (Tarde and Lorenc 2012, 53–54).

The properties of the liver are as much a result of its relations with other organs, tissues, molecules, and fluids within the body as they are with organisms, molecules, fluids, and forces outside. In our example, the separation of inside and outside follows only an analytical and perhaps semantic necessity, not an ontological separation of absolute spaces.

With the intention to compare another medical model and how it conceives liver function and its glycogenic capacities, let us look beyond the biomedical model we have described and describe, very briefly and surely incomplete, some components of liver physiology under the traditional Chinese medical model. The Yellow Emperor's Classic text of Chinese medicine describes the physiology of the liver in terms that suit very well the biomedical understanding of the glycogenic function of the liver, and they did so thousands of years before Bernard's discoveries by torturing dogs.

"The liver stores blood. During the day, the liver provides the blood for movement and activities, so that the blood can circulate throughout the channels and collaterals. At night, when one sleeps, the blood returns to the liver. When the liver is nourished by the blood, one can see. When the feet are perfused with blood, one can walk. When the hands are nourished by blood, they can grasp. When the fingers are provided with blood, one can carry." (Ni 1995, 43)

The Chinese medicine method, as other "traditional" medical models, is not experimental but speculative, and it conceives the human body as a mirror to the larger forces within the milieu [49]. Blood in Chinese medicine has a distinctive meaning and function than for the biomedical model. It is not pertinent to go more into it at the moment, but the "nourishment" function of blood in Chinese medicine parallels, in the example, the physiology of glucose giving energy to tissues under the biomedical paradigm.

As we see in the physiology of glucose and glycogen within the liver, insulin and the pancreas play a crucial part in maintaining "normal" levels of glucose in the bloodstream, but of course it was not more crucial than the glucose we were provided with after digesting the breakfast. Diabetes, as pathology, is diagnosed clinically by higher-than-normal concentrations of glucose

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[49] The quote that follows is a good summary of how this particular medical model -Traditional Chinese Medicine- conceives flows and processes within the organism as a correspondence with forces at large in the universe (milieu).

"Chinese medicine really is a classical scheme of knowing. In addition to the circulation and balance in the body, and between the body and the universe, of blood, essence, and qi, Chinese medicine is based on a theory of systematic correspondences. The health of the state functions like the health of the body (a metaphor that has pervaded medical discourse in China since Huang Di's Inner Classics of the first or second century BCE). Harmony can be disturbed by excessive desire or gluttony; by external conditions, such as a change in temperature or environment; or by the invasion of evil influences or spirits. Harmony is achieved though the maintenance of the flow of blood, essence, and qi through the body—and, in the case of qi, through immediate and extended environments… A similar school of thought saw the world's dynamics as based on the interactions of five phases (wuxing) or five categories of all things material and immaterial. Wood, water, fire, earth, and metal represented more than the physical elements—they were also phases, each with their own set of characteristics, and related to each other in a cycle of conquest and generation. Applied to the human body, five-phases theory explained the dynamic relationships and affinities of five basic bodily systems, loosely associated with liver, heart, spleen, lung, and kidneys. The liver stored the blood; the heart regulated the movement of the blood and governed consciousness; the spleen stored and regulated energy from food; the lung regulated the qi of breath and also kept internal and external energy in their proper channels; and the kidneys governed reproductive function and the stores of primordial qi, the original source of life.1 The yinyang and five-phases schools were synthesized during the first or second century BCE and came to characterize Chinese medicine. The body, with its organs and processes, functioned like the natural and social environments surrounding it" (Schonebaum 2016, 15).

For another analysis of Chinese Medicine as a "Correlative Science and Technology Studies" see also (Lin and Law 2014).

in the blood, but it is intrinsically conceived as the exhaustion of pancreatic ß-cells that fail to produce the levels of insulin that will lower circulating glucose levels, mostly converting it into glycogen. This is true for both types of diabetes (I and II). Could thinking beyond an "internal" milieu (like we have done with the glycogenic function of the liver) change the way we conceive –prevent, diagnose, treat– a disease like diabetes?

To sum up what we have attempted to explore in this section, let us go back to the image of the physiology of our liver. We left many things out of the story of how our liver stores and produces energy for our body. In the example, we tried to present the liver as intimately related to our entire body, the artichoke, city, woodchips, and the garden. If we had mentioned more detail about the bus driver, then probably her liver would have been more evidently related to mine. What about other organs and other bodies we will never know about, close by or far away, that participated in growing, caring, preparing, shipping, delivering, and selling the breakfast that gave us the initial glucose to start the workday? Turning the questions from our liver to a phenomenon like diabetes, how different can it be to analyze what happens to glucose within our bodies and its milieu beyond discussing a list of risk factors associated with developing insulin resistance? It seems like a daunting task since it will involve going well beyond biological experimentation and molecular interventions. It will have to include, for example, a critical examination of how the body (who develops diabetes) spends its days working, playing, suffering, loving; what food comes into his mouth, where it comes from, and how it gets there; and what, if anything, is preventing his body to recover a "normal" autopoietic physiology of glucose before irreversible damage is inflicted on his tissues. This gaze shifting to the milieu where medical phenomena takes place opens the door as well for us to point at the political issues of the modern hegemonic biomedical model. Why is there such an intense interest in gaining knowledge of the molecular intricacies of insulin (enzymatic in general) and immunological physiology? What can we gain, and what can we lose, by these approaches?

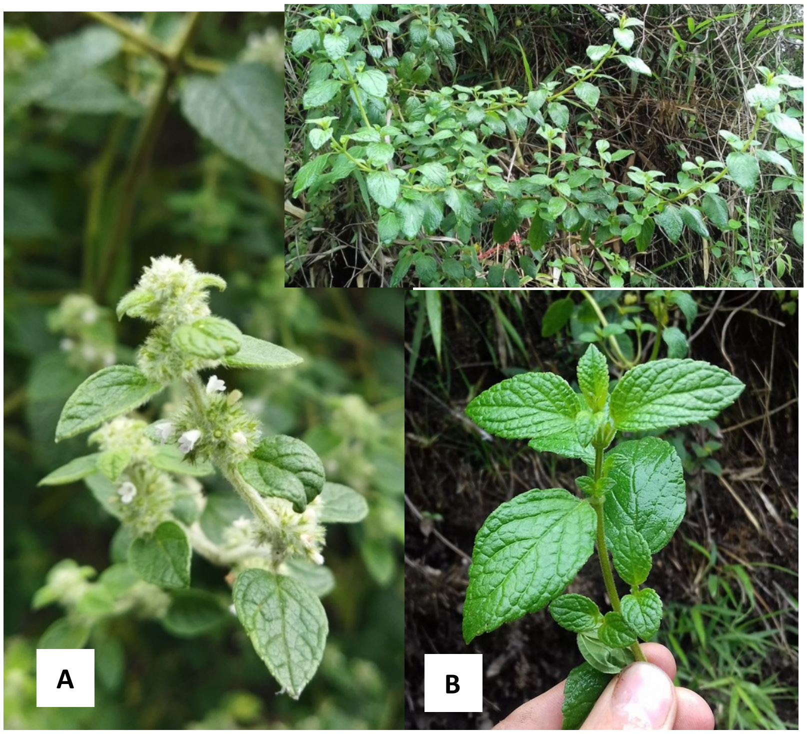

Image 4. iNaturalist. Observations of Minthostachys Mollis from Los Alpes, Ecuador. Observed on 5/11/2021 (A) and 1/4/2021 (B). Exported from www.inaturalist.org/observations/78733478 (A) and www.inaturalist.org/observations/67597820 (B) on 7/6/2023.

Encounter 6 – Tipo - Minthostachys mollis

El generoso tipo, también se ha escuchado que lo llaman tifo, pumín, muña... En latín le dicen minthostachys mollis.

Aromática, fresca, ligeramente dulce, con afinidad para sistemas respiratorio y digestivo. Esta hierba se ha vuelto fundamental adición a nuestra farmacia. Gran parte de todo este proyecto ha sido escrito bajo su relajante influencia.

En época de flores es más diaforética y respiratoria (A), en crecimiento vegetativo (B) parecería trabajar más en la digestión. Siempre es un té delicioso, una sorpresa que llega como un aroma inesperado pero bienvenido al atravesar una cerca, o cruzar el umbral de un chaparro.

Regalo de los bosques nublados andinos, le encantan los caminos y los bordes de trochas hechas por los humanos. Parece como que le gusta crecer directamente a la altura de la ventana de nuestro carro, para recolectarlo sin ni siquiera bajarnos, ofreciéndose y recordándonos que debemos llevarlo siempre fresco para la familia.

The two chapters that follow, Healthpolitic and Healthycology, are an experiment in thinking with health into dimensions that are visible to contemporary human experience, and its ripples into planetary life. Both titles are neologisms, combining health with politics and ecology. The etymological origin of both words is the most direct explanation of our intentional use. Politics as pertaining to public affairs, governance, and public life; ecology as the science that studies the relationship with our collective home, *oikos*[50]. If the chapters of Part 2 that preceded dealt with the philosophical and theoretical predicate of the hegemonic medical model, these two sections take the hegemonic medical model for what it does to *us* (human and nonhuman, living and nonliving, organic and inert… a planetary us) and the impact that this medicalization of health has on our Terrapolis. Such impact is materialized in humanity by a change in the dynamics of oppression by medicalization. How this shift towards a new form of self-medicalized violence requires us to overcome patterns of thinking and acting that are no longer useful to defend ourselves from the new violence of 21st century globalized neoliberalism. Furthermore, beginning with apocalyptic narratives of the end-of-the-world-as-we-know-it, the presence of hyperobjects helps us understand why such forces (of planetary sickening) are hidden in plain sight, dismissed as imaginative conspirations, until they crush us. Our departure points for these two sections are not concepts or terms. Instead, we attempt to channel personal disappointment, close to a feeling of rage, against what has become of medical practice, and agriculture for that matter. Instead of being the tools and practices to help people traverse through a life of difficulties and challenges it has become, not in every aspect but at least in the ways we will describe below, tools of oppression, control, destruction, and they are succeeding in marring the experience of life as a journey of bliss and joy.

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[50] Healthycology as a term was taken from the name of the personal blog of UW graduate student Jonathan Childers -https://healthycology.wordpress.com/about/-. Jonathan was a teaching assistant in an environmental health course when we were global health students, and although his use of the term is not the same as ours, we are obliged to credit him with the neologism that we used in a philosophy colloquium we were invited. At the presentation, delivered in Spanish, we used the term “Salucología.” We have tried to maintain the writing style for this section as it was conceived, intended for public presentation or conference, oral.

2.7 Healthpolitic - Why overcoming medicine may heal society in the 21st century

"One has one's little pleasure for the day and one's little pleasure for the night: but one honors health. 'We invented happiness' say the last human beings, and they blink."
Thus Spoke Zarathustra (Nietzsche 2006, Part II, Ch 15)

Following Nietzsche, it is the task of the philosopher to create new values and overcome ourselves beyond good and evil. The political act occurs at the moment when the border between what *is* and what *can be* is blurred, (Rancière 2011b, 14), when "good" and "evil" is rewritten. Can there also be a political act in relation to our health? There is no point to debate whether there are political rationalities at play within our bodies and beings, rather what kind of political rationalities are at play in relation to our individual and collective health.

For this section, we will borrow from a new set of authors to abstract three distinct levels of political rationalities at play: external, biologic, and psychological. This means that we can discuss three different types of health politics, where three types of medical power are evidenced: disciplinary medicine, biopolitical medicine, and psychopolitical medicine. For this section, we will attempt an exploration on taking Michel Foucault's bio-politics (Foucault 1979; 2008) a step further into Byung-Chul Han's psycho-politics (Han 2014).

For epistemological reasons and given the theoretical basis intended to be used for such analysis, health and disease are not opposed, rather contrasting ends of the same spectrum. The limits between health and disease constitute a difference between sameness. In Rancière's terms: dissensus. "There is politics because the common is divided" (Rancière 2011b, 1). The aiming direction of this approach is to get closer to the idea of "Medicine", and what that may mean. Furthermore, what is at stake by defining medicine in the form that our all-knowing late-modern neoliberal medical and scientific discourse does? There are a wide variety of assumptions arising when we discuss "medicine" or "health" or any particular type of "pathological condition", several of them related to geopolitical, historic, cultural, and epistemological considerations that will require a critical and counter-hegemonic lens to clear up and analyze.

Let us depart with some definitions. Broadly speaking, and for analytical purposes, there are two types of "health". The first one is the health of the collective, of society. This is a condition of individuals and populations that society recognizes. This is the kind of health we usually discuss when talking about population or public health. We can discuss or observe this type of health, describe it in measurable components, and compare one's (at an individual or population scale) health to another's in the parameters we, as a society, contingently consider important and useful. These contingent decisions (of what health *is,* thus what is disease or ill-health) are embedded in a broader social context, involving aspects of historical, political, and cultural significance. For now, we will call it collective health. How we come to this contingent consensus (of what health *is*) is key to understanding the political nature of health and medicine (and public health of course). The importance we give to using Rancière's definition of politics as dissensus becomes then self-evident and helps the analytical process take shape.

There is another type of health that is more difficult to talk (write) about; and maybe there is no way to write about it while giving any justice to its significance. This health pertains to the individual person, comprised of the stasis and flow between elements that make up the organism, whose dynamic equilibrium then structures what we may call a medical "model". These models are also contingently constructed but they are at their core metaphors of indelible, and perhaps even metaphysical phenomena of self and being. Body, mind, and spirit/soul have been the modern triad in recent times. Traditional Chinese medicine has the five phases *(五行 Wǔ Xíng; or fire, water, wood, earth, and metal);* Ayurvedic medicine has the three doshas *(Vata, Pitta, Kapha)*; the Lakota medicine wheel has the five directions *(west, east, north, south, and center)*; the Hippocratic model the four humors *(blood, yellow bile, black bile, phlegm)*, and so on. Maybe we can refer to this as philosophical, or individual, health.

As a field of science, public health (and epidemiology) works on collective health. Individual health concerns everyone; "medicine", however, makes healing her specialty. Medicine's imperative is *to act on* ill-health. Action is again closely related to the political act. Although speaking in relation to aesthetics, Rancière speaks of action "not [as] the simple expenditure of energy. It is the use of the appropriate means to ends" (Rancière 2011a, 242). In terms of what we know as "modern medicine", the recreation and enforcement of its particular ways beyond the individual organism, collective health (therefore all our relations) has also been "medicalized". This medicalization of society has now, in late-modernity, expanded from external societal politics and our internal biopolitics into the realm of psychopolitics. Haven't we heard from countless sources of the new "epidemic" of mental health disorders, or stress, or burnout? Those are all psychological collective pathologies that cannot be explained anymore by Foucauldian biopolitics. Agamben speculates in the introduction to *Homo Sacer* that "Foucault's death kept him from showing how he would have developed the concept and study of biopolitics" (Agamben 1998, 10), therefore inviting us to expand into the limits of biopolitics in late-modernity that Foucault himself began to present in his lectures in the late 1970's and early 1980's (Foucault 2008). Inspired by the texts of Byung-Chul Han (2014; 2015a; 2015b; 2016) we will try further along this chapter to explain what we mean by this shift into psycho-politics.

How does modern medicine define what disease is and what is healthiness? "To act it is necessary at least to localize." We have already pointed to this geographical statement that comprises the first words of the massively influential work of Georges Canguilhem (Canguilhem 1978, 11)[51]: the notion of what is health, or healthy, is constructed by a creating a topology of normality[52]. This normality is based on criteria that we can observe, measure, and quantify. Consequently, the events or situations that drift away from this normality are consequently called disease, or ill-health in its many forms. It is a (quantitative) account of normality since bodily states and functions can go either to excess or to deficit: hyper or hypo. As it becomes evident, this is a two-dimensional relationship, either more or less, up or down. It is a Cartesian view of health and

[51] Originally published in 1943
[52] We already discussed Canguilhem's notion of the *normal* in section 2.1.

disease. Not only Cartesian but positivist and reductionist in its core, and Canguilhem goes a long way in making his theory on the philosophical assumptions of modern medicine on the Cartesian work of Auguste Comte and Claude Bernard. Canguilhem's largest contribution to our present approach, as he was to Foucault and many others (Foucault 1978), is that he calls on these fundamental epistemological bases of modern western medicine not to define medicine itself, rather as a tool to dive into science and society at large. He does so by debunking everyday assumptions of what medicine (and science) is. For example, many would say that medicine is about "curing" disease without any real understanding of what they are saying by disease or by cure. Following what we stated previously, "curing" is, in medical terms, returning the organism to the constructed state of what was defined as "normal". In many ways, modern western medicine constructs health under a basis of an unspoken "consensus" of normality, or healthiness. Once again we see the connections of medicine as police, or policing, as implied in the work of Foucault (Foucault 1973; 1979; 2008) as well as Rancière (Rancière 2011b).

Canguilhem and Foucault focused on modern medicine, but their analysis is insufficient when recognizing that late-modern medicine has particularities that have changed as the capitalist world system has mutated along the current globalized economic system: neoliberalism. Medicine now goes beyond the realm of the philosophical and epistemological into everyday practice, and beyond our bare life into the inner workings of our own actions and reactions. Foucault's biopower works at this level as well, but it is still enforced from the outside. It is a power exerted on the individual from societal forces and policing institutions. Neoliberal medicalization of life constantly redefines these boundaries between health and ill-health from within, and it does so not in textbooks or publications, but through on-the-spot medical decisions and judgments that now go well beyond medical "practitioners" or physicians. This kind of medical power is enforced by the same individual upon which it is enforced.

This is what Byung-Chul Han call the shift from allo-exploitation to auto-exploitation (Han 2014; 2015a; 2016). In neoliberal late-modernity, everyone is [compelled] "free" to make such decisions. If external sovereign power had as its imperative Agamben's *state of exception*, or "*make die",* and if disciplinary biopolitics had the *must do,* or "*make live",* contemporary psycho-politics has the *can do, (make choose, make do, yes we can, be boundless, and so on).* The disciplinary subject is in neoliberal late-modernity transformed into the achievement subject. Psycho-politics is exerted in the *achievement* society that has supplanted *disciplinary* society (Han 2015a). If disciplinary society emerged with the shift of capitalist means of production in Europe's 17th century, achievement society has emerged with neoliberal capitalism in the globalized 21st century economy.

We now make medical, not necessarily health, decisions when we go grocery shopping, when we decide on the kind of career or job we are willing to do, when we decide how to spend the weekend, when we shoo away smokers from streets and parks, when we decide on our hobbies, when we shift from watching news to watching satire, and so on. All in the name of health and choice, effectively serving the neoliberal pursuit of limitless efficiency and self-entrepreneurial exploitation. Furthermore, what is interesting about our late-modern medical decisions, this self-re-engaging with healthiness happens inside our psyche when we guilt ourselves for our "un-healthy" desires or blame ourselves for our "risky" choices.

Latin-American critical epidemiology and social theory has been denouncing this "riskification" of life by capitalist medicine since the 1970's (Almeida Filho 2001; Barreto, Almeida Filho, and Breilh 2001; Breilh 1986; 1998). In other words, we are compelled to define our normal, therefore our pathological, constantly, and incessantly. *Homo sacer* has evolved in the late-modern political citizen to the *homo sanum* (¿?). In the neoliberal medicalized society exploitation can occur without domination (Han 2015a), it occurs through the individual's seductive obsession with healthiness.

Medical decisions are political decisions. The act of constantly pursuing the boundaries of the normal, the healthy, keeps individuals in the neoliberal society in an ever-increasing cycle of self-exploitation. That is what is at stake with our intention to explore the possibility of reclaiming that decision space, liberating the medical decision from allopathic hegemony, and redefine healthiness. By attempting to redefine healthiness we intend to redefine medicine, disease, and healing. Healing the collective is not enough, but perhaps liberating individuals from their own health burden can be the most profound and emancipatory political act in contemporary medicalized society.

Encounter 7 – Trébol Rojo, Trifolium pratense

Espectorante, sedativo, nutritivo. Uso para tos espasmódica y bronquial. Espectorante principalmente en niños. Tiene fama de usarse para mejorar la calidad de sueño y para síntomas de menopausia. Muy benigno, se pueden tomar en altas dosis. Increíble atrayente de bungas y abejorros del bosque nublado. Se lo propaga con siembra directa o al darle de comer sus semillas a las vacas. Otro aliado "introducido" que nos acompaña en la tarea de trabajar para la abundancia de los bosques nublados y valles interandinos.

Image 5. iNaturalist. Observation of Trifolium Pratense from Los Alpes, Ecuador. Observed on 6/29/2021. Exported from https://www.inaturalist.org/observations/85049714 on 7/6/2023.

2.8 Healthycology – health in times of … hyperobjects

The image with which we want to start this section is a variable image, but at the same time constant in Christian modernity, and it is the imminence of the end of times.

Image 6. Mushroom cloud – DeviantArt.com, "End of the World", by alexiuss, Published Sep 28, 2016, https://www.deviantart.com/alexiuss/art/End-of-the-world-637060188

We are going to present some examples of the multiple image of the end of the world. We say this because despite being multiple, it is the same image, the same story, the same discourse, or the same narrative. Multiple but not plural.

Despite the world being destroyed, in this representation apparently by some beautiful mushrooms of probable human creation, there is a witness, someone (probably a man) who observes the catastrophe and who would seem to not be afraid of the situation, appearing secure enough to turn around and walk towards a future to be constructed.

Sometimes this image, of the end of the world, supported by the collective imagination of patriarchal, capitalist, Eurocentric Christian modernity (read Hollywood drama), comes suddenly with a disaster. Because that is a disaster, dis-aster, a star that goes out of place and disarms us all of structure and security. And this is the panic that we have as a Western modern society, the disaster is coming and the world, as we know it, is ending. And this is the part that we sometimes forget about the discourse, and we believe that it is the most decisive and important part, the world that is ending is the one we know.

John speaks: Rev 6:13 “And the stars of heaven fell unto the earth, even as a fig tree casteth her untimely figs, when she is shaken of a mighty wind.”

All of these and many more narratives or stories are what we could call "images of the end of the world." Of an end of the world imagined as possible and imminent, but that we are not there yet. We can still be saved, redeemed, if only we repent and confess our sins. We have to accept that we are a confessional society, as Foucault analyzed in depth in the first volume of History of Sexuality (1990). Psychologically we need confession to redeem the disasters that we know we are causing.

But some, ourselves included, propose that these images of the end of the world can be seen differently, they can be seen in much more latent everydayness, and they are not in a hypothetical future.

Image 7. The end is near, but far away.

Left: McFarland, Lori. "Arctic Sea Ice Thins, So Do Polar Bears." Sandhills Sentinel, February 1, 2018. https://sandhillssentinel.com/climate-change-diet-arctic-sea-ice-thins-polar-bears/.

Right: Kerstin Langenberger Photography, August 20, 2015, Image post, Facebook, https://www.facebook.com/kerstin.langenberger.photography/photos/a.463697036975575.115901.429056113773001/1045109095501030/

They could be seen, for example, as images that appeal to a sensitivity also constructed by postmodernity, of appealing to guilt to stimulate action, again the ghost of Christian morality lurking. With these types of images, which are real there is no doubt, but what we want to convey is that they feed into this idea that the end of the world is close to us, although not quite here yet. It is already reaching these poor bears who are clinging to life with their nails, but that is far away in the Arctic, so we can still do something to save ourselves here nearby. We will hardly find charismatic images of how some insignificant lichen disappears in the Andes or how a millennia-old language has few elderly speakers left, or any other curious depressing fact that will surely be quite easy to find.

Image 8. Another image of the end of the world. Marcin Balcerzak (Photographer). (2022, Jan 19). "A professional looking at a Genetically Modified corn cob" [digital image]. Retrieved from https://www.scienceabc.com/pure-sciences/what-are-molecular-scissors.html

There are also more images of the end of the world, like the previous one, that are not in the future, but that could rarely be presented as part of this narrative that the world is ending. That someone has to wear respiratory and contact protection to analyze a food, is also an image of an end of the world.

Perhaps because, and this is a bit of the proposal of where we are going to advance in what follows, the end of the world as we know it is happening, and it has been happening for some time now.

And towards the end of this section, we want to reflect on what happens to us collectively and individually, by perpetuating this history of the imminence of being at the gates of the end of the world.

Anyway, everyone can recognize in their own way how images and stories of everything ending abound in our daily lives. Some may be more subtle than others. These end-of-the-world narratives always have something in common, and that is that humanity is portrayed as both the center and protagonist of both the causes that have led us to this point and the actions that can save us.

Humanity, recognizing the singular but multiple planetary crisis, as a consequence of our collective actions, decides to fall into the Chinese finger trap. When their fingers are trapped in this trap, their reaction is to pull harder and more determinedly outward, without recognizing that this only tightens the device and makes the fingers more trapped than before. In other words, we feel that since we screwed up, we, and only we, can fix it.

Sustainability, paraphrasing Brazilian activist and intellectual Ailton Krenak, is nothing more than the new method for postponing the end of the world (Krenak 2020). It is the paradox of humans in the Anthropocene: we recognize that we have agency and responsibility to act because we recognize that we are lethal.

One way to understand the ubiquitous narrative of the impending end of the world as we know it is through the concept of hyperobjects (Morton 2013b; 2013a). Timothy Morton proposes the idea of hyperobjects as things (objects) that are so large (or complex) that a certain distance is required to be able to see or understand them. This required distance is necessary to be able to view them with a perspective and information that goes considerably beyond human "reality," or the self-involved ontology that places humans at the center and end of existence.

Hyperobjects are things "that are massively distributed in time and space in relation to humans." (Morton 2013a). Hyperobjects have a series of characteristics: they are viscous, meaning they stick to the things they relate to, or the more you try to escape them, the more you are inundated by them, like a Chinese finger trap; they flood discourses and are often not easy to define, so you can't even have a banal conversation about the weather with your neighbor without someone mentioning global warming; they are non-local, meaning that no local manifestation is directly the totality of the hyperobject, but perhaps a sample of it.

These hyperobjects manifest themselves through the relationships between other objects. Additionally, hyperobjects are generally not visible or representable in their entirety, so we need partial representations of their consequences, or measurements and observations through technological tools and information processing.

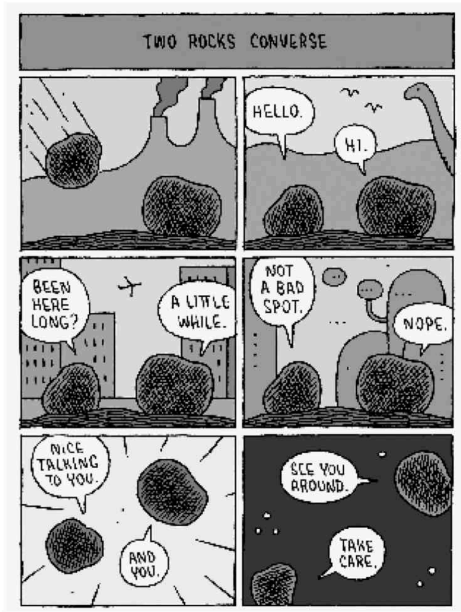
It is interesting to think that the same era of information and technological revolutions is somehow responsible for our ability to comprehend the existence of hyperobjects. For example, the satellite image of the BP oil spill in the Gulf of Mexico shows how humanity now has the ability to monitor and observe these gigantic forms of subterranean substances that have come to the surface, as well as the ability to produce them.

Image 9. Deepwater Horizon oil spill captured by NASA's Terra satellite on May 24, 2010. Humans now have the ability to track gigantic fluid forms such as this— and the ability to make them. (Morton 2013a, 33)

The most important consequence of this ability is understanding how recognizing the existence of hyperobjects obliges us to consider a relational object oriented ontology (OOO) (Harman 2002) that goes beyond humanity and above all to eradicate the dualities of human-all-too-human ontology, such as the distinction between human-nonhuman, nature-society, organism-environment, and so on.

An example of a hyperobject that Morton loves to repeat is global warming. We cannot see it or really know what it is; what we can see, and measure are its consequences. We recognize it through measurements of other objects (carbon concentrations, temperature and glacier coverage patterns, climatological patterns, etc.) that suggest its existence. And if it exists, even if we lock ourselves in our idealized bunker inspired by the Hobbit's shire, we cannot separate ourselves from its influence.

Humanity has always been aware of enormous objects or entities that go beyond our conceptual abilities, but there are peculiarities in the realization of novel objects such as hyperobjects. The peculiarity of these entities is that they force us to situate ourselves in our place on the planet and in the cosmos. Hyperobjects seem to oblige us to certain things, to think irreducibly, and to shake up our central ideas of what it means to exist.



Tom Gauld, *Two Rocks Converse* (2010).

Image 10. Two rocks converse. Tom Gauld (2010), Cited in Morton 2013, 57.

With the arrival of hyperobjects, many things have come to an end. With global warming, the glaciers have come to an end, and with the hyperobject of RNA viruses, effusive greetings with kisses and hugs have come to an end. But a critical component of the hyperobject called global warming, or even the hyperobject called SARS-CoV-2, is the historic and now incomprehensible distinction between Nature and Society, or Nature and Human, to put it another way.

Here are some references to works in anthropology and sociology that make very clear observations about how this division has always been erroneous, perhaps part of forced exclusive dichotomies, thanks to social scientists taking Newtonian science too seriously, in which the universe is composed of objects that collide with each other like ping-pong balls in a closed space.

Eduardo Viveiros de Castro talks about some historical stimuli for this turn towards ontology beyond the human, including the crisis of representation (a problem that goes back to Kant with his transcendental idealism). A problem that is visible in the gap between how we perceive the world around us, of which we are a part, and the very existence of this world.

In an anthropology close to OOO, Viveiros de Castro makes a provocation when presenting what he has defined as Amerindian Perspectivism. In his book *Cannibal Metaphysics*, Viveiros de Castro (Viveiros de Castro 2014) proposes that it has taken Western modernity centuries and bloodshed to understand how the conception of nature as an inert object (once again, Christian morality, in which the creator has gifted us with all of creation to be dominated for our use and enjoyment, aided by the scientific arrogance of believing that the phenomena of reality can be reduced to singular, measurable, and modifiable components) is what has brought us to this planetary crisis.

In the dominant modern metaphysics, the world is composed of a single nature within which there are many cultures or societies. That is, there is something big "out there" within which live the multiple human cultures, as well as the societies of a forest, of ants, of viruses, molecules, the water cycle, etc. We are either multiculturalists or mononaturalists. The Amerindian perspectivism, Viveiros de Castro proposes, explains how the planetary reality is composed of a single culture, that is, a single society that comprises all living beings, non-living objects, and even entities that inhabit other dimensions of perception and existence.

But the reality or materiality in which these objects and beings live is different for each one; each one exists in the nature that their perspective allows them. We cannot see the world like a worm, and the perspective of time that we share with a rock is necessarily anthropomorphized and metaphorized. This is Amerindian perspectivism; it is multi-naturalistic. That is why it can be conceptually understood that a river is a relative, or that a tree is a grandfather. After all, materially and scientifically speaking, we are all soil transformed by sunlight into different manifestations of the same thing: can we call that life? But for these different manifestations of this unique planetary culture or society, only a portion of reality is accessible to each. While we are human and not worms, our perspective is that of a human. There are multiple natures that are beyond the reach of our existential or sensory perspective, although there are ways and mechanisms (rituals, substances, or other aids) to access these other perspectives, something that is not always desirable or achievable for everyone. Why would we want to see gamma rays?

The presence of hyperobjects makes us think about the gap between appearance and reality that all objects suffer from, or the impossibility of comprehending the real existence of things. We know that this sounds like we are idealizing the indigenous peoples of America and demonizing Christian modernity, and well, we recognize that there may be something of that. But identifying this hegemony of multiculturalist thought that objectifies nature and is perhaps the philosophy responsible for the crisis of planetary health (and note that we are not only talking about COVID) is not the same as blaming Europeans or moderns, not even Christians in general. These ideas of Amerindian perspectivism have strange similarities to purely Western thoughts, the example here being the concept of hyperobjects.

This externalization of nature by hegemonic thought thus contrasts with a conviction that nature cannot be what is "out there" because there is no such division between inside and outside. If we had focused on the philosophy of health and medicine, as we do in other sections, we could think that this division was extended to include organism-environment as one of the basic premises of the hegemonic medical model, something fundamental in the creation of the normal and its separation from the pathological.

Now it is time to try to present something like footnotes to a hyperobject that we will call, for now, an "RNA-based hyperobject." Some of the following discussions are the traces we see of the manifestation of this hyperobject. We cannot see it, of course, we see its image under an electron microscope, but to begin with, when we see it, it is just there peacefully in the Petri dish. How do we see the RNA-based hyperobject when it mixes with the genetic material of a human cell?

We cannot separate ourselves from these beings, we have vaccines for some, but vaccines for the vast majority of these are a shot in the dark due to the enormous mutagenic variability they have. This hyperobject is not local. This is almost the definition of a virus; it is a lipid envelope with 3 or 4 identified structural molecules containing 13k nucleotides of RNA. For useless comparison, humans have 3.2 billion base pairs of DNA.

In other words, it is so small and simple, in relation to our reality as macroscopic mammals, that its spatiality cannot be delimited. It is here in this geographic area, or in this body, or on this mask, or in this cell. Its size and spatiality are hyper-small, a manifestation of this unnamed hyperobject. And finally, it does not have human temporality, it has temporal variations that are unreachable or at most speculative for us.

Now let us focus on the manifestation of this hyperobject. Of the eighteen known subtypes of influenza A, some live in both pigs and birds. It is a virus that mutates frequently and occasionally makes a species jump between pigs, birds, and humans. When a new strain that only existed in one species jumps for the first time to another, an epidemic occurs.

In industrial farming, as we see in many places, millions of animals are confined in places with living conditions worse than we imagine the aliens will have with us.

These animals are genetically remarkably similar, due to "genetic improvement", animals are selected for their growth rate, weight gain, etc., to the point where a breeding pig can be the father of millions of animals. They are practically clones. Their growth is accelerated by this genetic selection, feeding, and hormonal and antibiotic medications (required for these living conditions to allow some life).

So, let us add up, and we are going to think that we are an influenza virus. We have millions of organisms in a closed space with poor ventilation and constant humidity, with similar genetic and nutritional characteristics, that is, immunity. If a viable mutation emerges in a year, our ability to reproduce will be beautiful!

Adding to the cramped conditions, the low genetic variability, and the mobility around the world, the pressure to make chickens grow as quickly as possible, which is already around 40 days, evolutionarily eliminates viruses with slower infection rates, and selects for viruses with greater lethality and infectivity. In short, we are not only raising pigs and birds, but also viruses. (Wallace 2009). Speaking as the virus, these humans have created the most favorable conditions for our existence and distribution around the world.

Another manifestation of this hyperobject is what we do not see. The externalities produced by the economic model that drives these dynamics cannot be seen on a day-to-day basis, and neither can the person who eats an industry chicken or gets sick from one of these viruses directly see these connections. The investment trading market is a fundamental agent of this hyperobject, which is also difficult to see, but in which the financialization of production and the commodification of these animals turn them into values to be traded while they are alive, not just in death.

The animals are committed to capital months before their actual birth. These commitments extend beyond their mere identities as products on the trading floor; the species are treated as asset classes subject to price volatilities and the ecological or epidemiological dynamics in which the real animals would eventually be born. As a result, breeding, birth, and development are deliberately and logistically inclined to meet the market's projections first.

Another externality of this production system, and another fragmented manifestation of the hyperobject we are talking about, is the waste produced by these intensive animal productions. A concentration camp in the age of hyperobjects.

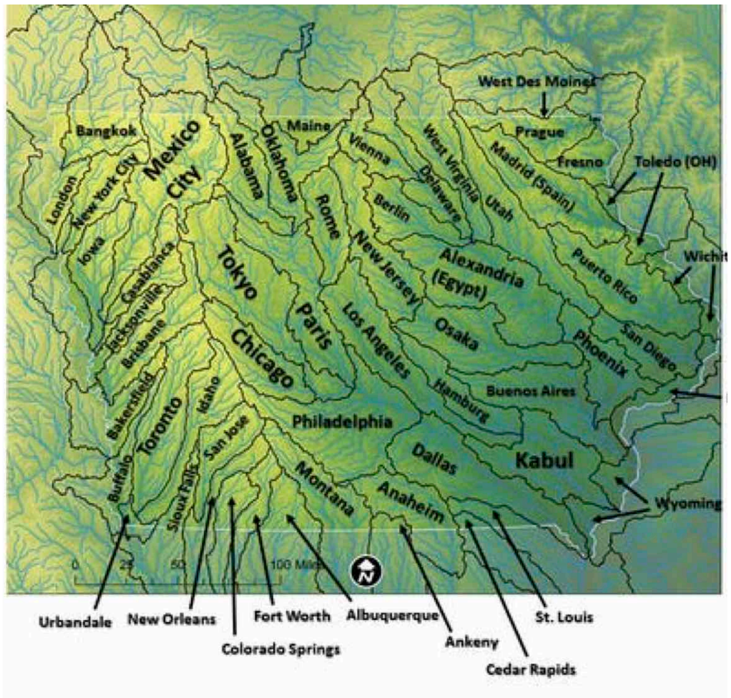


Image 11. Iowa's real population.(C. Jones 2019)

This image represents the amount of waste produced by a population (feces). A human produces X amount of waste in their lifetime, so the amount of waste produced by a population in general is calculated. This graph was made by calculating the waste of each of these watersheds in the state of Iowa based on the amount of waste generated by people, pigs, chickens, and cattle located in those territories. Thus, a "human population equivalent" was derived for the Iowa watersheds. In a state with a population of three million, its waste is equivalent to that of several of the largest cities in the world.

Let us stop with the examples of manifestations of this hyperobject, and let's close by returning to the initial themes of this section regarding the end of the world. The manifestations of this object are so complex and diverse that we cannot even begin to formulate a response or propose a reaction. But we can start to see that there is something that is manifesting in many of these things, and for example, with the coronavirus pandemic, it is knocking us down. It is humiliating us. To the ground...

"What is eerie is that we discover global warming precisely when it is already here. It is like realizing that you have been living on the expanding periphery of a slow-motion nuclear bomb for some time. You have a few seconds to be surprised as the fantasy of having lived in a small, clean, and perfect world fade away. All those apocalyptic and fatalistic narratives about the 'end of the world' are, from this point of view, part of the problem, not part of the solution. By postponing the inevitability to a hypothetical future, these narratives inoculate us against the very real object that has entered into the ecological, social, and psychic space. Hyperobjects condemn us now, not at some future date." (Morton 2013a, 103–4) "The titanic of modernity collides with the iceberg of hyperobjects." (2013a, 19)

Image 12. Life emerging from the ruins of the Anthropocene. (Photo by author).

The understanding of hyperobjects leads us to an ontology beyond human ontology, which means that it forces us to think in terms of relationships between objects and to overcome the ontological dualities that have defined our relationship with the natural world. This understanding implies a shift in our way of thinking and acting, and it obliges us to consider the complexity of ecological systems and the interdependence of all forms of life on the planet.

Sustainability, as an idea, becomes a way of dealing with the complexity of hyperobjects, but it can also be seen as a method of postponing the end of the world. The solution to the planetary crisis cannot be found in a single answer or approach, but must be approached in a holistic manner, considering the interconnection of all ecological systems and processes. Moreso, it requires us to shift ontologies and find the actual place of ourselves in the world.

Ultimately, the challenge we face involves changing our way of thinking and acting, overcoming our ontological dualities, and finding new ways to relate to the natural world and to each other as human beings.

among poisons and potions
medicines and fertilizer
how large the desire to emerge into the wild! into life!
tired we walk of thinktalk with no do
do is, perhaps, thinktalk in its most authentic
frontiers and bags
what is the way towards the earth?
seems that the direction is down
below, to the ground, to the roots
but if life is there, the road begins with the breath
Inhale. Inspire. Inoculate.

Image 13.Digital AI art generated using Midjourney with the poem above as a prompt. Image under CC License. https://discord.gg/midjourney

The end of the world, the doom, is not in the future. Some of the medical phenomena in contemporary times seems to fit very well under the theorization of a hyperobject in times of unraveling doom, but it is up to the reader to decide what to do with such analysis.

Our proposal for the reader is to understand that hegemonic medicine in contemporary times at the first quarter of the 21st century, still does not have its philosophical foundations cleared up. Medicine suffers from chronic and, perhaps intentional, amnesia of its origins, basing the conceptualization of the body and human experience by a mixture of 19th century theorizations that tried to translate the findings of 15th-17th century physicists and philosophers. All of them European but globalized as universal truths. Despite the incredible advances in genetics, molecular biology, surgery, imaging, and lifesaving interventions that could not even been imagined less than a century ago, modern medicine is failing since its goal of making us live longer is not necessarily making us live healthier. That is our central claim for Part 2, contemporary hegemonic medicine fails because it is acting like a blind person swinging a sword in the dark, aiming towards where they hear voices or sounds, and the lights are beginning to shine on the mess it is leaving behind.

We accept the presence of doom but refuse to give into it. The end of the world (as we know it) is now. We acknowledge the doom but remain optimistic about the future. That is why Part 3 exists. We aspire to overcome ourselves and the world to build anew. We do not capitulate on the practice of medicine, we pursue the practice of a different medicine, hybridized with the practice of a different agriculture. Another medicine and another agriculture are possible. Another world is possible. It must begin from the ground.

PART 3 – SOIL AND AUTOETHNOGRAPHY

3.1 Soil, minerals, and microbes

Soil is a living organism, not only capable of recreating and sustaining itself, but also capable of creating and sustaining life. Ana Primavesi presents the four key requirements for plant life (Primavesi 1984): 1. Energy – Sun; 2. Water; 3. Elements required for its products such as sugars, starches, proteins, lipids – Carbon, Oxygen, Hydrogen, Nitrogen, Phosphorous, and others; and 4. Elements required for its substances, also called enzymes – Potassium and a range of "micro" nutrients such as Magnesium, Manganese, Iron, Zinc, Copper, Boron, and others). Reflecting on these four requirements for plant life, we see that soil is not only the medium to acquire but also the source and storage of all these requirements except for the sun.

Being a complex, diverse, and dynamic organism, it is exceedingly difficult to approach any discussion of soil with the ambition to completely cover all its intricacies, compositions, and processes. One way of diving into soil is to try and analyze it with three constituents that encompass most of its ingredients and processes, without forgetting that such effort is still an abstraction of soil in order to be able to represent it and understand it in ways that may be useful for our purposes and curiosities. Broadly speaking and taking our cue from soil people in latinoamerica such as Jairo Restrepo, Ignacio Simon, and others, soil is composed of three spheres or categories of things, the three Ms: Minerals, Microorganisms, [organic] Matter.

These three Ms interact and relate to one another, and their relations are the foundations for the sustenance of plant (and therefore animal) life. Notice we omit fungi here, because they are both macro and micro-organisms, and the vast majority of them play a role within the M that stands for microorganisms. Fungi are a form of life that play an integral role in the sustenance of plant life. Although the same argument can probably be constructed towards plant life sustaining fungal life, that is just more evidence towards a symbiotic thinking of how life creates and recreates itself.

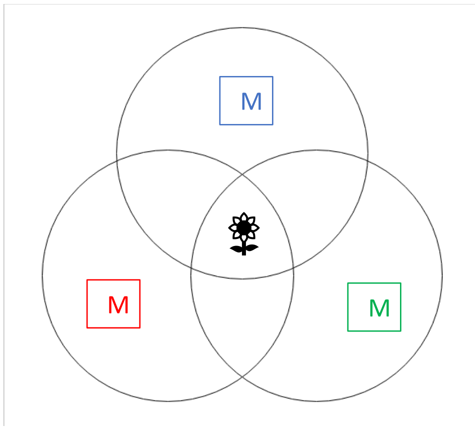


Figure 1. A graphic photograph of the relations of these three M's (Minerals, Microbiology, and organic Matter) is what is represented in a chroma. Figure by author [53]

When discussing soil, we are inevitably reducing soil to a composite of describable factors, elements, and constituents. The relations among each of these will be sometimes explicit and will appear here and there, but they are limited not only by our narrative capabilities, but also by this initial reduction of an infinitely complex and unknown entity in a set of conceptual forms, as well as into the limits of language. These descriptions may be complexified further when we include personal ethnographical observations of working with and around soil, as well as try to convey some of the hidden and mysterious processes, the key processes involve the construction of soil fertility, through the visual representation that the chroma provides.

Following the particular example of the liver and its sweet properties to the living human body[54], we also see soil as an open-ended autopoietic system that relies on symbiotic relationships (with the living and the inanimate) to construct its ecological niche in the milieu. More clearly, such relationships continually create the milieu where they stand. By the process of continuously co-creating themselves and their environment, the living and the inert participate in a dialectical narration of the organism and its milieu through autopoiesis, symbiosis, niche-construction, and adaptation. Just as the living human organism is embedded within a network of relationships that continually co-create its so-called "external" milieu and within the body's "internal" milieu, the

[53] More on chapter 3.2 Chromatography.
[54] See subsection on chapter 2.6 Milieu: Liver, glucose, and milieu construction.

relationships within soil processes and its wide range of actors are also co-creating the soil's milieu. [55]

Minerals

Diving into the chemistry of elemental particles in the way we have approached here was unexpected, but it is a necessity to have some tools for discussion and understand what we observe while working with plants and soil. Perhaps our reticence to see elements in their individual presentation was a consequence of seeing what quantitative soil analysts do, measuring quantities of single elements in detectable presentations. This is because when a farmer receives a soil analysis report that states that X element is high/low in comparison to the "expected" result, the kind of solution that comes forth depends on this approach of formulating the problem: add X element, in a soluble and absorbable form, to correct the excess or deficiency of the desired element[56].

However, we will be discussing elements in their individual forms, and how they play a role in healthy soil and plants. How to use or work with these elements in the actual agricultural practice is where controversy arises, and the imperative originates to rethink our approach to be on the side that works for life and abundance.

When talking about "macronutrients", they are the three main elements required because of their larger quantitative proportions in the process of most plant life. These are Nitrogen [N],

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[55] This paragraph can by a brief synthesis of Chapters 2.1, 2.2, 2.3, and 2.6.

[56] The reader should note this expression "soluble fertilizers" to refer to so-called chemical or industrial fertilizers. We call them soluble because that is what differentiates them from the fertilizers we manufacture and use (see section 3.3), also misnamed "organic." We use plenty of chemistry, and chemicals are a wonderful and natural thing, present everywhere and comprising the matter of the universe. The reason we call our products "bio-fertilizers" is not because they are not "chemical," but because they are usually made up of living things, mostly microorganisms, which interact with chemicals (metabolism or mineral chelation) to produce life. Soluble fertilizers have as their main intention to deliver a particular amount of element X in soluble form disregarding soil interactions between the three M's.

Phosphorous [P], and Potassium [K]. We are omitting[57] the macro-macro elements within life on Earth, Hydrogen [H], Oxygen [O], and Carbon [C].

Nitrogen - N

Of all the essential chemical elements within soil life, and subsequent plant life, nitrogen plays a significant role. N abounds in the earth's atmosphere with close to 78% of air composition. In every living cell, regardless of the kingdom to which it belongs, N is an indispensable constituent of protein and of the nucleic acid molecules that allow life to be life as we know it. DNA and the proteins it synthesizes are heavily based on N, therefore cellular metabolism, reproduction, growth, and everything that makes a cell do life-like functions, requires N. It is no surprise then that of all the chemical elements in the soil, N is required in larger proportions, and its availability is almost like a defining marker of the uptake, use, and metabolism of other elements within microbial life as well as plant life.

A more complete discussion of the role of N within life processes should require a dive into proteins, a very essential component of living tissue with functions that range from structure and form, communication and signaling, change and adaptation, growth, and metabolism. Paradoxically, N as an element is an inert gas, with a distinctive historical etymology that means "without life": azote. Azote, in Castilian, also means a whip or a plague. If you breathe an atmosphere exclusively with N (that is low or no oxygen), you will die. But then how is it that an inert gas finds its way to living protein within living organisms, allowing for plant life to thrive and health to be present and sustained in the ecosystem called planet earth? The answer is simple with complex folds of meaning: through the soil. The fixation of elemental N by soil microorganisms (mainly bacterium) that live in symbiosis with a wide range of plants and fungal species, is arguably the most important chemical process for life sustenance on earth, perhaps second only to photosynthesis.

[57] And this omission is intentional, since in what follows of this subsection, we are emulating the common industrial and extractive (may we dare say mechanistic) approach to agriculture and soil health.

A very curious fact is that N fixation from atmosphere to the soil happens (as far as we know) naturally only by some of these microorganisms, that we will discuss further when we dive into that M[icroorganisms], and by the energy of lightning. The element that moves life: N, transforms for the use of the living through two of the most powerful energy sources on earth: lightning strikes and microbes. The other most powerful energy source on earth also mobilized N through a high energy process, humans.

N also works directly in stimulating the action of other key elements such as P and K. However, an excess in N can delay a plant's growth, diminish its nutritional qualities, and lower its resistance to disease processes, trophobiosis[58]. For this reason, N needs to be balanced in its relations to other elements within plants and soils.

Before diving into how the agricultural industrial complex has managed to deal with N and fix It for plant use, let us briefly discuss the N cycle in the soil in a few steps:

1. Nitrogen fixation: Atmospheric nitrogen gas (N_2) is not directly usable by most plants. However, certain bacteria and archaea can convert N_2 into ammonia (NH_3), a form of N that can be taken up by plants. Some of these nitrogen-fixing microorganisms live in symbiotic relationships with certain plants, such as legumes, while others are free-living in the soil.

[58] Trophobiosis is the theory states that the susceptibility of a crop plant to pests and diseases depends on its nutritional state. Pests and diseases will not attack a healthy plant. The health of a plant is directly associated with its internal balance, which is constantly changing. According to Chaboussou (Chaboussou 2004, n. originally published in 1985), it is not just any plant which is attacked by pests and diseases, but only those which could serve as food for the insect or pathogen. In other words, the cultivated plant will only be attacked when the food these pests need is available in the sap. If a plant has sufficient quantity of the substances which are food for the pests and diseases, it is because it has not been cultivated in an optimal way. (Guazzelli, María José et al. 2007). Synthetic pesticides act upon the physiology of the cultivated plant, which affects resistance to various pests. Pesticides are in fact poisons, not only for the pests they are designed to attack, but also for the host plant. Their damaging effects are linked to inhibition of growth and to enrichment of plant tissues with soluble substances, such as amino acids, which provide a nutritional base for the development of various pests (insects, fungal, bacterial, and viral diseases). "Plant protection should therefore be investigated, not by means of attempting to destroy the pest, but rather by stimulating the plant's own resistance." (Chaboussou 1986). The importance of trophobiosis and the implications it can have for our current work on the relations of human and planetary health to soil and plant health are enormous. Writing a more in-depth analysis and review of the theory could have been a departure point for the whole dissertation. Given this importance, we are also leaving this as a reference for future work and writing.

2. Ammonification: When plants and animals die or produce waste, their organic nitrogen compounds are broken down by decomposer microorganisms, such as bacteria and fungi, into NH_3. This process is called ammonification.
3. Nitrification: NH_3 is then converted into nitrite (NO_2-) and then nitrate (NO_3-) by other soil bacteria in a process called nitrification. NO_3- is the form of N that is most readily taken up by plants. Nitrification is an aerobic process that occurs in the presence of oxygen.
4. Plant uptake: Plants take up NO_{3-} ions through their roots and use them to build proteins and other important molecules. Ammonium (NH_{4+}) and NO_{3-} are the two compounds that allow plants to uptake N in the soil. NH_{4+} oxidizes rapidly into NO_{3-}, so NO_3- is the form usually available to plants. Lightning changes N_2 into NO_3-.
5. Denitrification: In oxygen-poor soils, some bacteria can convert NO_3- back into atmospheric N_2 gas through denitrification. This process occurs when there is not enough oxygen available for aerobic respiration. This can also happen by volatilization, or the transformation of soil N compounds back into N_2 or gas ammonia NH_3-.

The history of how we (humans) came to develop a process to synthesize N from the atmosphere and create soluble forms that could be applied on the ground is an interesting drama that connects human ingenuity, opportunity, war, and destruction at the same time. Adam Romero provides an excellent review of this story, in addition to other uses of agriculture to serve as a "profitable sink for industrial waste" (2016b). Its history connects military industries, petrochemical industries, pharmaceutical industries, and agricultural industries.

In what follows, we will try to convey a brief and surely incomplete account of the historical aspects of N in agriculture and chemistry and how it came to be the most heavily applied element in its soluble forms for agricultural practices. The consequences for soil health of such practice are neglected in this section, as they are for those who advocate for the use of soluble N in massive quantities for production of food. What we can advance is that when embarking on agroecological practices, the dogma that nitrogenated soluble fertilizers are the most fundamental limiting factor of how productive a soil can be, is absolutely disregarded. Plant growth is not determined by availability of N, as we have heard agronomists insist (so they can sell nitrogenated fertilizers). A farmer that works with soil that has a good relationship across the three M's, and a healthy and abundant organic matter that is produced, decomposed, and humified in-situ, has no concern about N depletion or deficiency. This previous statement has been proven by us[59] before the incredulous eyes of agronomists and neighboring farmers that thought that efficient farming was only possible using a technological invention of the mid-20th century. Let us understand a little what was this invention about.

Ammonia NH_3

In 1913 factories began to synthesize ammonia NH_3 using the Haber-Bosh process. Ammonia synthesis is conducted by a reaction of hydrogen and nitrogen at elevated temperature. The first Haber-Bosch unit was an iron catalyst operating at 3000psig and 1000ºF. The key step in this process is the determination of the synthesis gas, a cheap source rich in N and H. Initially coal or coke were the only available raw material. Their gasification led to a mixture of H and N. In the 1920's the process to create methane CH_4 from carbon monoxide CO and H was perfected and using methane as a synthesis gas for ammonia became the standard process. By mid-20th century, most of the ammonia production was based on natural gas (Sauchelli 1964, 50–52). Where natural gas is not available, crude oil and residual fuel oil are processed to create the synthesis gas. Coal, the original raw material for it, is now used on a much smaller scale. In the 1960's, plants that can synthesize 600 tons per day were constructed, (Sauchelli 1964, 60) but presently the large plants produce about 8,000 tons per day[60].

The process of creating NH_3 was further developed to include phosphorous, with the synthesis of ammonium phosphates. In addition to the synthesis of N-P compounds, it was realized that the incorporation other substances to the process such as Sulphuric acid, ammonium sulfate, or potassium salts, could produce an almost infinite number of N-P-K granular compounds[61]. Adding

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[59] See Figure 4 and Figure 5 on page 149.

[60] "Fertilizer Outlook 2020-2024", International Fertilizer Association (IFA), 2020. Available online at: https://www.fertilizer.org/Statistics_IFA/Fertilizer_outlook.

[61] A brief note explaining the N-P-K nomenclature as devised by the agri/pharma industry. The three numbers represented in commercial industrial formulations of soluble fertilizers reference proportions of the compositions of weight of the three macroelements in the compound. For example, a fertilizer 10-0-0 contains 10% N and no P or K. That means that a 40 kg sac of this fertilizer contains 4kg of N in soluble form. A 40 kg sac of fertilizer 10-30-10 contains 4kg of N, 12kg of P and 4kg of K. The proportions can never add up to 100, since it always contains

urea to the process could also create high N compounds (30-30-0). A limitation of this process of making these ammonium-type fertilizers for producing high N compounds such as 18-46-0 or 16-48-0 is that the acids used need to be relatively pure. Once successful attempt to overcome this is to carry out another ammoniation step using a process called TVA. The Tennessee Valley Authority (TVA) launched an ammonia-from-coal project in 1975 at a time when natural gas shortages had caused ammonia prices to soar. The TVA method used excess ammonia to achieve a mole ratio of ammonia and phosphoric acid of 2:0, basically scrubbing the excess ammonia from the drums with phosphoric acid. (Sauchelli 1964, 150–53).

Synthesis gas, and the petrochemical origins of synthetic ammonia production

The primary source of synthesis gas (syngas) in the petrochemical industry is from the processing of natural gas or other hydrocarbons. The most common method of synthesis gas production is through a process known as steam methane reforming (SMR), where natural gas is reacted with steam in the presence of a catalyst to produce synthesis gas. The SMR process involves heating natural gas to a high temperature and mixing it with steam. This mixture is then passed over a catalyst, typically nickel, in a reactor chamber. The reaction produces a mixture of hydrogen, carbon monoxide, and carbon dioxide, which is synthesis gas. The syngas is then separated and purified for further use in the petrochemical industry. (Chen et al. 2019). Other hydrocarbons like

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"fillers", usually sands, salts, or other silicates used to dilute, buffer pH, or prevent caking or dusting of the compound. The industry doesn't disclose on the labels the exact components of this "fillers," and agricultural engineers (aka salespeople), don't seem to mind this. The largest proportion of available N in these fertilizers is urea, delivering close to 46% N, so for instance a fertilizer 30-0-0 is a heavily nitrogenated fertilizer. There are more nuances to this, for example the P used in these compounds is not pure P, but usually a compound as well such as phosphorous pentoxide P_2O_5, and K as potassium oxide K_2O. This means that if a fertilizer is labelled 10-10-10, you need to take this into account and realize that the ratio, by weight, of P within P_2O_5 is about 43%, so a 40kg bag of this fertilizer is not really 4kg of P, instead [(0.1 x 0.43) x 40] 1.72kg. Similarly, the ratio of K in K_2O is 83%, so in the same example as above, the 40kg sac of the 10-10-10 fertilizer actually contains [(0.1 x 0.83) x 40] 3.32kg of soluble K. These calculations, as the discussion in much of this section, reveals a common way of thinking about soil and crop needs in a purely quantitative approach, almost mechanistic we might say. The industry thus presents the mineral needs of plant X measured in Y quantities, prescribing the farmer the exact compound needed for such development. An approach that disregards the complete picture of what soil is, not only basing their focus on only three main chemical elements, but also neglecting the facts and functions of microbiological life in the soil, and the metabolism that occurs across the soil's fauna, flora and funga, and their relations and interactions (metabolism). The power of soluble fertilizers, such as the NPK formulations, is undoubted and can be evidenced by any farmer, but our claim is that it is bad science, and with far reaching consequences, most of them beyond human comprehension. To fully understand the breath of our critique, the reader will need to see the difference in approaches to soil health and fertility as presented in section 3.2.

naphtha, propane, and butane can also be used as sources for syngas production in the petrochemical industry. The choice of feedstock depends on factors such as cost, availability, and the desired composition of the syngas for specific applications. The same synthesis gas produced through steam methane reforming (SMR) or other methods in the petrochemical industry can be used as a source for the Haber-Bosch process for ammonia production[62].

The Haber-Bosch process, as described above, involves the reaction of nitrogen and hydrogen gases in the presence of an iron-based catalyst at high pressure and temperature to produce ammonia. In the Haber-Bosch process, the synthesis gas is typically used as the source of hydrogen, as it contains a high percentage of hydrogen gas. The synthesis gas is typically passed through a water-gas shift reaction to increase the proportion of hydrogen gas in the mixture. The resulting gas mixture, which contains a high proportion of hydrogen and carbon dioxide, is then reacted with nitrogen in the Haber-Bosch reactor to produce ammonia. The synthesis gas produced in the petrochemical industry is the critical component in the Haber-Bosch process for ammonia production. Without it, the production of ammonia would be much more difficult and expensive.

Urea - $CO(NH_2)_2$

The raw materials for synthesis of urea are natural gas, air, and water. Carbon dioxide is generally available from ammonia production. As for ammonia, the Haber-Bosch process is the base of all N based fertilizers, including the world's most commonly used chemical, urea. After the Haber-Bosch process produces ammonia, the ammonia is then reacted with carbon dioxide to form ammonium carbamate,

$2\ NH_3 + CO_2 \rightleftharpoons [NH_4]+[NH_2COO]-$

which is then dehydrated to produce urea.

[62] Through this we begin to witness the revolving doors of the petrochemical and agricultural industry, as different gears of the same extractive-oriented mechanism.

$[NH_4]^+[NH_2COO]^- \rightleftharpoons CO(NH_2)_2 + H_2O$

In the first step, ammonia and carbon dioxide react to form ammonium carbamate. This reaction takes place under high temperature and pressure and is catalyzed by an appropriate catalyst. In the second step, the ammonium carbamate is dehydrated to form urea and water. This step also requires high temperature and pressure, and a catalyst is used to increase the reaction rate.

Although urea can be synthesized by various processes, historically this main process was called the BASF process. The 1922 BASF urea process refers to the industrial process for the production of urea fertilizer, which was developed by the German chemical company BASF in 1922. The BASF urea process allowed for the industrial-scale production of urea with high purity and at lower costs. The process involves the use of a high-pressure synthesis reactor, which allows for the reaction of ammonia and carbon dioxide at pressures of up to 200 atmospheres and temperatures of up to 180°C. The 1922 BASF urea process quickly became the dominant method for the production of urea fertilizer and remains in use today, with some modifications and improvements. It has played a significant role in the development of modern industrial agriculture, as it allowed for the mass production of fertilizers.

Urea has the highest N content of any other solid products (45 % total N). Its popularity also responds to its easiness in handling and storage, lower leach rates in soils, and its low corrosivity to synthesizing and spreading equipment (Sauchelli 1964, 252–57). A kilo of urea with 45% N content gives 35% more N than ammonium nitrate and more than twice as much ammonium sulfate. Additionally, urea is completely soluble in water and so it can be applied in irrigation waters.

Phosphorous - P

Another of the key chemical elements in the soil regarding its ability to sustain life is phosphorous P. In the periodic table of elements, P is located below N and is a non-metallic element that can exist in several different forms. Phosphorus is an essential nutrient for all living organisms and is a key component of DNA, RNA, and ATP which is the primary source of energy for cells. It is also important for bone formation and growth, as well as for the transfer of genetic information during cell division.

P stimulates cellular growth in plants, increases immunity and resistance to disease, promotes root development, and accelerates maturity in plants. P is easily processed by soil microbiology and an abundance of P stimulates rapid growth and diversity of microbiological life in soils. Adenosine triphosphate (ATP), is a key molecule in both photosynthesis and biological respiration, using three P atoms, allowing for living cells to store and use energy through the chemical reaction by the movement of electrons within cellular or intracellular membranes.

Since P does not occur naturally as a free element, it makes more sense for us to discuss it in the forms that it occurs. It reacts highly with H and O, creating mostly phosphate compounds. The most common and fully oxidized form is as a phosphate PO_4^{3-} (Pi), and Pi reacts with a wide range of other elements such as Ca, creating calcium phosphate $Ca_3(PO_4)_2$.

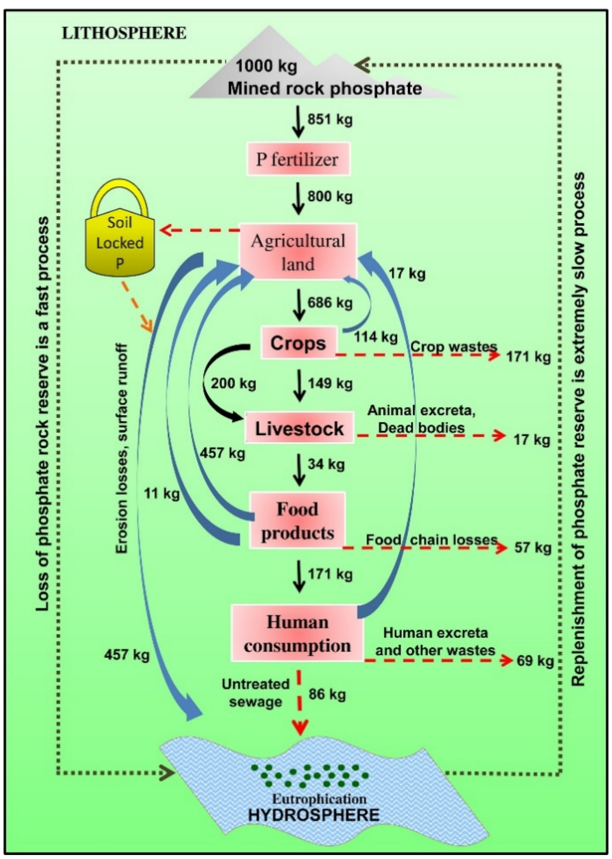

Figure 2. Schematic representation of flow of P from source to sink.(Achary et al. 2017)

Figure 2 highlights the distribution, flow, and loss of P for every ton (1000 kg) of rock phosphate mined from the underground reserve. The P losses from various points are depicted by red dashed lines. (Achary et al. 2017)

Phosphate and phosphite

In 1769 J.G. Gahn and C.W. Scheele showed that calcium phosphate $Ca_3(PO_4)_2$ is found in bones and obtained P from bone ash. Lavoisier recognized P as an element in 1777. Bone ash became the major source of phosphorus until the 1840s. Phosphate rock, a mineral containing calcium phosphate, was first used in 1850 and following the introduction of the electric arc furnace in 1890 this became the main source of phosphorus. Phosphorus, phosphates and phosphoric acid are still obtained from phosphate rock. (Lambers and Plaxton 2015)

In the human body (similarly to other mammals such as cattle), P is found in a wide range of tissues, the most abundant one being calcium phosphates in enamel, dentine, and bone[63]. P is also found in salivary and dental calculi, urinary stones, tumoral calcifications, and even in tuberculous lesions and prostatic deposits. Initially the raw material for P production was animal bones, later replaced by mineral phosphates. The bones or rock were dissolved in Sulphuric acid to give phosphoric acid and calcium sulphate as a by-product. (Sumaiya Al Ghuzaili, Anna Jesil & Saravanan 2019).

Interestingly, phosphate is the main element in some of the most murderous agrotoxics, all the family of organophosphates. For instance, the phosphonate "glyphosate" (roundup) – *N*-(phosphonomethyl)glycine– is a phosphate-based compound that inhibits the function of an amino acid producing enzyme EPSP (5-enolpyruvylshikimate-3-phosphate synthase).

This history is key to our purposes since sources for P for agricultural production and soil supplementation from sources other than phosphate rock are hard to obtain, and it is usually considered a limiting factor for agroecological practices that want to stay independent and autonomous from industrial processes. Contrary to widely held belief, N is not a problem in any agroecological practice, if the soil that sustains your crops allows for a healthy N cycle, it will never be a problem. We mentioned this previously in the Nitrogen subsection, but the obsession that the agricultural industry has in force feeding the world its industrial waste in the form of nitrogenated soluble compounds needs staunch protestation. We will discuss more of this aspect when we detail some practices that view soil as a living autopoietic entity. With P, it is not the same story, as the P cycle in nature has a different rhythm and we, as humans committed to build

[63] See the subsection "Phosphites from bone" on chapter 3.3.

and maintain the fertility of the soil that is feeding other beings and us, need to actively introduce it and mobilize it within soils and crops.

As we see from the history of obtaining P from bone ash, there is a source for P out there available to all farmers. It is important to make a distinction of P in the phosphate form PO_4^{3-} *Pi*, with phosphite $[HPO_3]^{2-}$ *Phi*. Phi is a reduced form of phosphate Pi, in which a hydrogen atom replaces an oxygen atom bonded to the P atom. Phi has been widely used as a systemic, phloem-mobile oomicide to control crop diseases caused by various oomycete species belonging to the genus Phytophthora (McDonald et al., 2001a; Lambers and Plaxton, 2015). However, P in general, is used by the plant in many processes, one of the main ones being in their immunological defense, mainly against biotic stress (stress caused by biological factors such as insects, fungi, and potentially pathogenic microorganisms). (Mehta et al. 2021)

Pi is a nonrenewable resource that has been speculated to last for approximately 70-200 years if current consumption is maintained (Cordell and White 2011; Achary et al. 2017). Also, P in its Pi form is largely unavailable for plant absorption since it binds chemically to calcium and iron making it "immobile." It is common to see a relatively high, or even excess amounts of P in a soil analysis test, and still show signs and symptoms in plants of P deficiency. Therefore, it is no surprise that the application of excess Pi fertilizers has become a routine practice by farmers receiving council by agricultural industry.[64]

To Pi or not to Phi

We have been able to witness a sort of controversy in the benefits of using Phi or Pi for soil/plant nutrition. In the Phi molecular structure, a hydrogen atom replaces an oxygen one. This substitution results in significant differences affecting the behavior of both molecules in plants. According to McDonald et al. (2001), in Pi, the P atom is located at the center of a tetrahedral molecular geometry, with the oxygen atoms distributed at the points of the structure (one

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[64] Working with P has been an interesting experience, and the lessons we obtained from this work have been particularly rewarding. We began by writing an "Encounter with phosphorous," but shortly realized that we needed to expand on it. The following subsection *Pi or Phi*, and subsection "Phosphites from bone" in chapter 3.3 are the result of such work and lessons.

phosphorous atom in the middle of 4 oxygen atoms). The charge on the ion is distributed evenly among these four oxygen atoms so that the whole structure is entirely symmetrical from the four faces of the 3D structure. In Phi, the P atom is also at the center of a tetrahedron, although the molecule loses the symmetry observed in Pi. Both the shape of the molecule and the charge distribution seem to influence the binding of Pi to its interacting enzymes. Once Pi has bound to an enzyme, the remaining oxygen emerges from the surface, and thus becomes available to react with other molecules in the reaction catalyzed by the enzyme. Phi only has one face of the tetrahedron relatively similar to all the faces of the Pi 3D structure, so if it is to bind to the surface of an enzyme that normally binds Pi, it must bind at this face. When Phi binds to the enzyme surface in this orientation, it is the hydrogen atom bonded to the P atom that emerges from the enzyme surface, not an oxygen atom as in Pi. Thus, Phi cannot participate in the same biochemical reactions as Pi. (Gómez-Merino and Trejo-Téllez 2015; Achary et al. 2017).

In the early 1930s, it was concluded that Phi could not be used as a source of P by plants. After 40 years, Phi has returned to the market as an efficient fungicide against the Oomycota (i.e., species of Phytophthora and Pythium). Recently, Phi and phosphonites have captured the market as fungicides against phytophthora and other fungal diseases, providing a strong protective effect by activating defense mechanisms in plants. Bayer Crop science has marketed fungicide containing Phi as an active ingredient under two world-famous brands: Aliette and Fosetyl-Al. They, Bayer and company market Phi as a fungicide, since their business is death *(-cide),* but the science shows us that it does not kill fungus, instead it allows plants to activate their physiological response against particular fungi.

Claims suggesting Phi may fulfil the functions of Pi are unclear. Therefore, on the one hand, some phosphates that are utilized as fertilizer do not affect plant diseases, while on the other hand, Phi is useful for managing diseases but will not provide plants with their required phosphate. In Andean tropical soils such as the ones we work, P is not scarce at all, so applications of Phi serve mainly as an immunological more than a nutritional approach. So, the question is whether Phi is a fertilizer or a fungicide. (Ratjen and Gerendás 2009).

Image 14. Jairo Restrepo demonstrating the production, function, and chemistry of Phi. Detail on this process in section 3.3. Photo by author.

Alternatively, for radical agroecological practitioners such as Jairo Restrepo, the answer as to what roles Phi plays is more straightforward, leaning to the side of a wide range of actions that can be classified into the very non-specific term "bio-stimulator"[65]. P is required by plants not because it may be able to "kill" pests. P works for plants because it helps them to find their own immunity. This idea lands within the concept of trophobiosis[66]. Summarizing this theory, trophobiosis demonstrates that there is no such thing as a pathology, a pest, or a disease. The phenomena of sickness or ill-health anywhere (a human being, an individual plant, a crop field, or a human population) is seen as a signal or a sign of an underlying imbalance in the plant environment and nutrition. With this framework, nothing really needs to be killed or attacked, but careful observation, understanding, and balancing of the relations across the three Ms to avoid what we can call pathogenic processes for plants (or humans, or populations).

Potassium - K

Potassium was first isolated from potash, the ashes of plants, from which its name derives. In the periodic table, potassium is one of the alkali metals, all of which have a single valence electron in

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[65] This was presented initially on a weeklong workshop attended with Jairo Restrepo in Ecuador on March 2019. Subsequently, this has been a theme of continuous conversations within agroecological chatgroups, other workshops, and visits with friends and colleagues embarked on the practice and production of an autonomous (free from industrial dependencies) agricultural practices.

[66] See footnote 58 on Trophobiosis.

the outer electron shell, which is easily removed to create an ion with a positive charge, a cation, which combines with anions to form salts. The symbol K stems from kali, itself from the root word alkali, which in turn comes from Arabic al-qalyah - "plant ashes". Kalium has been another proposed name for potassium, and it is still used in some languages.

K works on plants by promoting healthy root systems as well as promoting plant maturation. It is key in the formation of starches and chlorophyl. K's main function in plants and animals is not to be synthesized into organic compounds; rather, it activates enzymes. It is the activator for over eighty enzymes responsible for living functions. Potassium always remains in the ionic form as well, soluble in water and easily absorbable by roots. Potassium is also linked to plants having a good response to environmental stress. It improves a plant’s hardiness, drought tolerance, and disease resistance. This is an essential nutrient to help plants flower or produce fruit.

Potash

Potash includes various mined and manufactured salts that contain potassium in water-soluble form. Where soils are naturally rich in potassium, the application of potassium solubilizing bacteria as biofertilizer for agriculture can reduce the use of chemical fertilizer and support sustainable agriculture. A large number of saprophytic bacterial and fungal strains have been identified which solubilize potassium from insoluble forms like mica, feldspar, and others by microbial production of substances which can either directly dissolve rock potassium or chelate silicon ions to bring potassium into the solution.

Potassium is taken up by plants against its concentration gradient through K^+ transporters and channels located in the plasma membrane of root cells (Ashley et al. 2006). Potassium can be stored, both in the cell cytoplasm and the vacuole, and the distribution among these two locations is the major factor for determining the K function in the plant (Marschner 1995).

Freeze/thaw and wet/dry cycles help to stimulate the exchange equilibrium of K. Lime application generally increases soil pH and potassium fixation. In acidic soils, colloids are holding H^+ ions preventing K^+ from getting close to the exchange sites thus keeping K^+ from fixating. So as the pH increases, more K can be fixed to soil colloids. Another factor is root uptake—the more calcium and magnesium in soils the more competition these cations have for root uptake and thus less potassium could be absorbed. No element works in isolation of other elements as they would in the lab, or in the mind of the agrochemical salesperson.

Due to its enzyme activating capabilities in plants, we can say that K is a key element in helping plants adapt to their environment and conduct different processes that help them respond to stimulus or stresses in their milieus. For the case of abiotic stress, drought is the single most critical threat to world food security, affecting vast areas of agricultural lands. K helps crops use water more effectively. Adequate K availability helps plants develop deeper roots to access water at greater soil depth, creates higher osmotic gradient within cells for faster water uptake, and speeds the closure of the crop canopy that results in more water accessible to the crop. The plant's ability to increase K+ fluxes and reduce Na+ fluxes in the presence of salinity to attain a higher K+/Na+ selectivity ratio is essential for salt tolerance. Frost damage is inversely related to K concentrations, and the increased K soil supply improved the plant frost resistance by the increase in phospholipids, membrane permeability, and improvement in the biophysical and biochemical properties of cells (Hakerlerler et al. 1997).

For the case of biotic stress, K also plays a key role. Potassium deficiency manifestations, such as thin cell walls, weakened stalks and stems, smaller and shorter roots, sugar accumulation in the leaves, and accumulation of unused N, encourage disease infection. Each of these maladies reduces the ability of the plant to resist entry and infection by fungal, bacterial, and viral disease organisms. A plant with free and abundant sugars and N in their tissues are delicious for insects, therefore a plant well-nourished with K is able to sequester sugars and keep tissue concentrations of N low, basically starving our plant-eating insects. The basis for trophobiosis. A healthy plant, free from stress and adapted to its milieu (both abiotic and biotic contexts), is much more resistant to disease attack.

Silicon - Si

Silicon is the second most abundant mineral element in the earth's crust, after oxygen, and it is a constituent of almost every rock material on the planet. In the soil, silicon is dissolved by the action of organic acids produced by microorganisms within humus. The main acids involved are ascetic acid, citric acid, a full range of others within the carboxylic acids (molecules with the acid radical COOH), and the wide spectrum of humic acids and fulvic acids. The process of minerals being dissolved into soluble molecules by the action of microorganisms is called chelation - a process we become actively involved in with the production of mineralized biofertilizers.

Silicon forms structures within plants called phytolites and trichomes, compounds of silicon dioxide SiO_2, intervening in photosynthesis since they reflect and absorb sun light, hence incrementing photosynthetic activity. Silicon is a main component in glass and in grass. Keeping this in mind helps us understand the light absorbent/reflective capacities of silicon-based molecules on plants, plus the other physical properties of making a blade of grass "sharp", creating a defense mechanism on its own. A plant that is rich in silicon is more resistant to weather changes, insects, and any other biotic challenges.

In section 3.3, we will narrate how we can work with Silicon to react with Calcium in order to produce a bioavailable P in the never-ending work of building soil fertility.

Other trace elements

Magnesium - Mg

Stimulates the action of P. It is the key element within the chlorophyl molecule. A deficiency in plants produces a disease (or a symptom) called chlorosis, similar to anemia in mammals.

Calcium - Ca

Provides firmness to fruiting bodies, increases their weight and resistance to climatic changes. It is also a key element in the creation of buffer molecules to change or maintain the pH of a soil. Particularly important in the context of lime CaO.

Sulphur - S

A key element for life, works in the formation of plant tissue in general and is especially important for metabolic activity. Some plants, such as grasses, are more dependent on reliable sources of Sulphur.

Molybdenum - Mo

Works in partnership with N in the formation and synthesis of proteins.

Iron - Fe

Participates also in protein synthesis. In the soil, it produces compounds called siderophores, substances that microorganisms use to protect root systems from parasitic attacks.

Zinc - Zn

Key element in the formation of enzymes.

Boron - B

Participant in the formation of fruiting bodies in most fruiting plants.

Other elements within "rare earth" minerals

Minerals such as Lanthanum La, Europium Eu, Germanium Ge, Samarium Sm, and many others that intervene in metabolic and enzymatic processes. They participate in the production of substances called phytoantisipins, elicitors, phytoalexins. Their actions are mostly involved in the immune system of plants. In other words, their actions help plants navigate, negotiate, and interact with other biological elements in their milieu. Most times, the way we (humans) understand this is by thinking that plants use such substances to control, limit, or counteract the actions of other living organisms, mainly microbiological organisms.

Lime, and wrapping up on minerals

Lime, calcium oxide (CaO), is a chemical compound that is widely used in agriculture to improve soil health and crop yields. The origins and sources of lime can vary depending on the type, but it is commonly produced by heating limestone ($CaCO_3$) or other calcium-containing materials in a kiln. Other sources of lime can include hydrated lime ($Ca(OH)_2$) that is produced by adding water to lime.

There are several distinct types of lime that are commonly used in agriculture, including agricultural lime, dolomitic lime, and hydrated lime. Agricultural lime is the most commonly used type of lime and is typically made from ground limestone. Dolomitic lime is made from dolomite, a type of mineral that contains both calcium and magnesium, while hydrated lime is made from quicklime that has been mixed with water.

Compared to quicklime, hydrated lime is easier to handle and transport because it is a dry powder that does not react as violently with water. Hydrated lime also has a lower reactivity than quicklime, which makes it suitable for some applications where a slower, more controlled release of lime is desired. We have been able to realize that when acquiring quicklime for various chemical procedures we use for soil management, it almost always is hydrated lime despite the labels, being hydrated just by storage or transport in spaces with some moisture content.

Agricultural lime is a common product used to correct soil acidity, desired for particular crops. It is typically made from pulverized limestone or chalk and is composed mainly of calcium carbonate ($CaCO_3$) and magnesium carbonate ($MgCO_3$). Compared to hydrated lime and quicklime, agricultural lime is less caustic and less reactive. Hydrated lime and quicklime are both highly reactive and can cause burns or irritation upon contact with skin or eyes, while agricultural lime is safer to handle. Hydrated lime is also more water-soluble and quicker to react with soil, while agricultural lime reacts more slowly.

Lime can also help to increase the availability of other important nutrients such as phosphorus and nitrogen, by improving the metabolic capacity of microorganisms to chelate and transform these elements into substances within the humus, making them available for plants. Some agronomists in the field call this mineral mobilization, and this dynamic is what we look for within a reading of a chroma[67].

Lime can help to improve soil structure by increasing the aggregation of soil particles, which can improve water infiltration and root penetration. Lime acts both as a chemical agent as well as a physical agent. It sponges up clay soils, usually too hard and compacted; lime also gives consistency to sandy soils. (Rebolledo, J 1947, 22). The chemical actions we have described briefly, but following the three M triad, both chemical and physical actions impact on the capacity of microorganisms to interact with organic matter and minerals, brewing the substance of a healthy soil, humus.

It is also described that lime can help to reduce the toxicity of some elements in the soil, such as aluminum and other heavy metals (Martínez Madrid and Marrugo-Negrete 2021). The main problem of lime when used directly on soils is its overuse. Excessive use of lime can lead to an increase in soil pH, which can have negative impacts on plant growth and nutrient availability. A frequent problem for desperate farm owners (not usually farmers) that want a quick solution to decreasing yields and have the misfortune of being counseled by unscrupulous, or plain ignorant, agricultural engineers that only know how to sell products. The modern equivalent of salting the fields of the conquered enemy.

This problem does not mean that using lime directly for the soil is negative in any way. For example, we do a general "encalada," or liming, once every four or five years, depending on the pH of our soils, to keep them buffered. We maintain a high organic matter content, and our soils are continually fed with microbiological brews, with hundreds of animals manuring them constantly, which traduces into a considerable production of humic acids as the byproducts of microorganism metabolism, especially fungal. Andean soils in general are acidic soils to start with. When lime is applied on bare soil, with low microbiological activity due to high use of

[67] See section 3.2 "Chromatography."

soluble synthetic soluble fertilizers and all the *-cides*, adding lime can have disastrous consequences.

A key disadvantage is cost; lime can be relatively expensive, particularly for large-scale agricultural operations. In small and medium sized operations, when using quicklime or hydrated lime for brewing mineral broths, the main problem is the coordination of transport and storage. For instance, for some sulphate-based brews, the best quality (that is, most efficient chemical process and a more consistently pure product) will be obtained by using quicklime. Paraphrasing a statement repeated by countless farmers and peasants, and a brief recollection of our discussions on section 2.5 New Vitalisms, good enough is perfect. We use hydrated lime as second-best option, and even calcium carbonate if all else fails.[68]

This was a limited review of minerals and how to understand them. This review was motivated as a need for us to understand why we worked with chemicals and to comprehend the science behind the different strategies we were learning from agroecologists. These strategies are shared in section 3.3, as we learned how to do most of these before diving into the nuances of chemical reactions and elemental cycles. Before we can fully understand why a soil can be considered healthy, and why the recipes we implement worked on-the-ground, let us move onto another incomplete discussion of the other two Ms.

Microorganisms and Organic Matter

Let us focus our attention on the microbiology and organic matter Ms of the presented trifecta of soil phases. However, as the reader will note, the three Ms are present throughout our discussions of microorganisms as the three Ms are not really separate from the autopoietic unit presented here as "soil."

One study predicts there are 10^{12} microbial species on the planet, 10^{4} species have been cultured, and fewer than 10^{5} species are represented by classified sequences (Locey and Lennon 2016). Regardless of the actual number, what is clear is that we know a ridiculously small fraction of the

[68] More on this in section 3.3 "Working with soils." Specially subsection on brewing sulphuric potions

soil's microbiological life and even less about its relation to other forms of life above and below the surface. By far, the microorganisms that we know most about are those already categorized as "pathological," either for human or animal life or for particular cash crops. This is an indication of the theoretical and conceptual approach to soil science – more interested in disease than in health. Or, in other words, the study of health is approached by studying disease.

The undeniable fact is that microorganisms in the soil are never isolated as they are in a lab culture. These organisms are alive and in relation to each other within a community, where the actions of one impact the actions of another. This is what we call the "soil community", following the example of Ignacio Simón (2021)[69]. Industrial biological or organic preparations want to use exclusively the most active or most easily isolated microorganisms and disregard the zillions of microbiological lives that we are unaware of, or at least unaware of their names and particular actions. If we observe what happens in a healthy soil, of a forest for example, we find collembola, beetles, worms, fungi, actinomycetes, bacteria, protozoa, and a huge etc. that participate in the constant process of (de)composing organic matter and the chelation or metabolism of mineral matter. This is the essence of humus, where minerals meet microorganisms, and their metabolic acids and byproducts (broadly referred as humic compounds). Organic matter, after it has been metabolized by life, becomes humus, the living soil.

Humus, literal Latin word for "soil," is also the etymological origin of "human." We come from the soil, -dust thou art, and unto dust shalt thou return-. Humification is the process by which organic matter is transformed into humus, a dark, nutrient-rich substance that is a critical component of healthy soil. The process of humification can take many years and involves the action of various microorganisms, such as bacteria and fungi. The process of humification begins with the deposition of dead organic matter, such as plant debris, animal waste, and dead microorganisms, onto the soil surface. Over time, this organic matter is broken down by microorganisms, which release enzymes that break down complex organic molecules into simpler

[69] Ignacio "Nacho" Simón is a Mexican Farmer, agronomist, and soil scientist that had an important influence on our work with soil microbiology. We had the privilege to meet with him and discuss many of the aspects discussed in this section, as well as direct learning some of his microbiological broths, cultures, and experiences in a weeklong course together with Jairo Restrepo and Pacho Gangotena in Ecuador in 2019.

compounds. As organic matter is broken down, it releases nutrients such as nitrogen, phosphorus, and potassium, which can be taken up by plants. As the process of humification continues, the remaining organic matter is transformed into humus, a complex mixture of organic compounds that is resistant to further decay. The exact chemical and molecular processes involved in humification are complex and not fully understood, but it is thought to involve the formation of humic and fulvic acids, which are large organic molecules that are important components of humus. These molecules are formed through a process of polymerization, in which smaller organic molecules are joined together to form larger ones. After decomposition and decay of living (now dead) organic matter, humification is the return of the living to continue the cycle of abundance and health.

Overall, the process of humification is a critical component of healthy soil and plays a crucial role in maintaining the health of ecosystems. By transforming organic matter into humus, the process of humification helps to create nutrient-rich soil that can support the growth of plants and other organisms. Humus, and the organic substances that compose it, is what brings us the “forest” scent in healthy soil or compost. Working with microbiology and organic matter in the construction of humus can easily be the most rewarding phenomena we have ever experienced. The process is medical practice to soils, it is an alchemical event that lies on the transformation of death into life, from dead organic matter into the substrate of life on planet earth.

The soil community is broad and complex. The members of this community are usually called “micro,” but some are also definitely “macro.” They are macro either in their composite identity, such as a mycelium, or in their actions, but we will maintain the prefix “micro” despite being in many cases a misnomer.

The soil “community”

I am the **Nematode**, I feed on larvae from coleoptera and lepidoptera. Together with Trichoderma, we make a great team contributing towards root health.

I hunt bugs; I am a white fungus that you call **Entomopathogenic**[70] because my spores germinate within insect bodies and larvae that I use to reproduce.

I am **Rhizobium**, the cooking bacteria. I feed from sugar that gives me energy to produce ammonium compounds and nitrates that I give to my friend the root.

I am the soil **Worm**, the wiggler of the depths and surfaces. We come in many sizes and shapes. Some of us go deep and vertical and others go superficial and horizontal. We excavate by eating organic matter and prepare the way for mycorrhiza and root to follow behind.

I am the **Root**, I draw the nutrients from the soil towards the stem, leaves, flowers, and fruits of the plant. My micro friends help me digest and prepare most of the elements that I can't intake directly.

I live with the root; she gives me sugar and I extend my extremities through the soil to find water and the enzymes that my friend requires. I am called the **Mycorrhiza**.

I am **Megaterium**. They call me mega because I have a big head. I am a diligent worker, and I digest phosphorus that is close to the roots so that she can absorb it.

You call me **Azotobacter** because I take the azote gas, or Nitrogen, from the air and prepare it as non-volatile compounds on many plant roots.

I am called **Azospirillum**, with the same azote etymology because I love to take N from the air and fix it close to the roots of plants.

Call me **Beetle**. I come in many shapes and forms and spend some time underground while I prepare for metamorphosis. I hunt, dig, mulch, chew, and move many different materials around the soil.

[70] Most known kind of fungi from this class are the Cordyceps genus, recently made infamous by a HBO's TV series "The Last of Us" (2023) based on a 2013 video game of the same name.

My name is **Trichoderma** and I am a fungus. I am a hunter of different organisms that like to prey on roots and plants, so I am a big defender of roots. I extend myself on the soil and very close to plant roots where my prey likes to go.

I am also part of the community. I resist high temperatures, humidity, and aridity that others in the community can't resist. I eat everything I can find, so if there is not much around, I usually eat everything, and humans call me a pest. I am **Fusarium**.

On the "bad" members of the community

When giving any member of the community the label of enemy, a mechanistic perspective is purported. One that requires weapons and battles to overcome the enemy; much as if needing tools to repair a broken mechanism. Giving some nuance-though hopefully not confusion- to this aspect seems like an important discussion, and for that we need to recourse to a dangerous strategy: metaphors. We may combat and confront members of a community if our survival, or interests, depend on it, but as an adversary, not as an enemy. Adversary as one's opponent, not a hostile agent that is destined to destroy us. An adversary is someone that is following their own interests that happen to oppose or contradict ours. We, as humans, need to act diplomatically with our adversaries, because they are infinitely more powerful than we are. Not only are they more powerful, but the consequences of open and total war against them have scorched the fields that nourish us and our allies as well. Like Gandhi's phrase of leaving the whole world blind if we follow lex talionis. The industry that sells poisons (-cides) clearly has this perspective and it closely aligns with the hegemonic medical model that requires us to enlist in a war against germs and bugs.

A solution for a devastating nuclear war against microbiological enemies is to adhere to a vitalist perspective of trusting in the healing power of nature, and that every living being has a role that needs to be understood and respected. We need to understand our adversaries, in order that we can find ways to live with them, or how to make sure they can leave us -and our allies- alone. Our proposal is to avoid moral judgments of some members of the soil community as bad, and others as good; we also need to avoid seeing a sick crop, for example, as a mechanism that needs fixing.

We are taking a radical approach, following the vitalist approach of trophobiosis, to see a sick crop, or an adversarial microorganism, as a sign that is pointing us to a root problem that needs addressing. Usually, as experience has shown us, such root problems are not fixable broken parts of a system, but an unbalanced relation across the three M's that sustain life and health.

It is undeniable that some of the members of the community we gave voice to previously are sometimes detrimental to plant life: some of them do attack, sicken, and kill plants. The argument we want to introduce here is that they are acting based on the conditions that the community they are a part of is offering. The plant is, so to speak, offering itself to these predatory pests. Or in other words, these pathogenic microorganisms find themselves unchecked and unstopped in their functions of attacking vulnerable plant systems. Different metaphorical strategies should be used to present the facts without landing on a moral condition of being for or against any member of the soil community.

The moral aspect, however, is strongly present if we are to be honest about our perspective and positioning on any of these issues[71]. Beyond good or evil, we find ourselves undeniably "on the side of" plants if they are part of a crop we want to harvest and from which our livelihoods (either by eating it or by selling it) depend on. The same argument applies when a pathogenic microorganism infects a human body; we are definitely "on the side of" the human. What we are attempting to present here is therefore not an argument for selling all members of the community as "good," yet none of them as merely "bad." Can there be a way to analyze the members of the soil community from their perspective, and attempt to understand their actions and relations beyond the observable consequences of their actions? In other words, can we think as fusarium?

Let us imagine a living being, it can be either vegetable, fungal, or animal, within a particular milieu, which is experiencing some sort of abiotic stress. This can be a mineral disturbance, drought, flooding, an exaggerated application of soluble fertilization, etc. Any of these actions have a particular impact on the soil community. Some of them are more vulnerable to the

[71] A good place to remind the reader on the presentation of Viveiros de Castro's "Amerindian perspectivism" as we narrated on section 2.8 Healthycology…

experienced changes so they die off, and those that manage to survive find themselves in a "new" community composition. The milieu has changed. Finding less competition for nutrients or space, the survivors can reproduce at exponential rates unknown to previous conditions. In the tropics, the survivor of many stresses is usually Fusarium, and, finding its neighbors absent, it goes right towards the roots.

Ignacio Simon (2021) proposes that Fusarium, or Phytophtora, Plasmodiosphora, and many others, need to be relabeled from pathogenic to messaging (an even better terminology from our previous metaphor, from enemy to adversary). These community members are alerting the human that is taking care of the land that the community is altered; that is the diplomatic reading of the conflict. When soil analysis is being done, Fusarium almost always comes up, and the agronomist warns the farmer that her soil is "infested," opening the way for more agrotoxics that will further imbalance the soil community; that is the belligerent reading of the conflict.

An interesting sidenote on Fusarium is that some of its strains are producers of highly toxic mycotoxins and trichothecenes. The most commonly known mycotoxin is T-2, which was actively used in biological warfare by the USSR in southeast Asia during the 1970s, as well as by the US in South America together with glyphosate in the 2000s.

Fusarium is a fungus of the hyphomycetes, also known as filamentous fungi. In humans, it can create infections called "opportunistic," a term used for infections that affect the human body when the "community" of the immunological system is compromised. We wonder why the term opportunistic has not been used more commonly in agriculture, where the contexts where it arises are like the immunocompromised condition of a human body.

Fusarium oxysporum is the main strain connected to plant pathology in the tropics, which creates what is called the Panama disease in bananas. Fusarium has countless strains and it can also affect tomatoes and all the Solanaceas (nightshades), roses and flowers of the narcissus family (Rosaceae and Amaryllidaceae), and many more. In other latitudes, other strains such as Fusarium graminearum can affect barley crops. How humans decide to act based on that information that Fusarium or other "pests" are signaling will depend on the understanding that such humans have of life and health, and whether they have a sort of moral exigency towards the living, like the kind that vitalist thought teaches. Instead of killing Fusarium, the vitalist farmer would like to increase microbiological diversity, in particular Trichoderma, to counterbalance Fusarium activity in addition to an overall increase in organic matter content so that Fusarium can be well fed with decaying organic matter instead of feasting on our crops. That solution, however, is not immediate, and will take time and patience, a rare commodity when bills needed to be paid yesterday.

As it was previously suggested, labeling a member of the community as “bad” or as “enemy” is part of the war-like, belligerent approach that is the foundation required to maintain the profits generated by the powerful agro-chemical industry, which emerged in large part from the chemical companies and complexes developed during World War II (Romero 2016b; 2016a). The actual evidence points out that the bad members of the community are those that simplify soils, kill microorganisms by habit, unbalance mineral supplies, and disrupt the rhizosphere. They usually walk on two legs.

3.2 Chromatography

At this point it may be useful to the reader to take a step back and recall what we have explored so far[72]. We are about to embark on the first practical application of the theories we have exposed here and are advocating as medical work, health in a more-than-human dimension that intends to bring into the real world the conceptualization of soil as a living being, a living being as part of the milieu we are constantly creating and pertain to, a medicine for abundance of life.

Chromatography in a few words: a map of the living soil. A map towards the health of a soil. In not so few words, a chroma is a crosscut photograph of the state of the soil at the time of a sample collection. It is, first and mostly, an aesthetic analysis that requires an interpretation. An interpretation that connects the image (made up of colors, shapes, and patterns) with 1. the context and history of the soil, 2. those who have worked on and with (sometimes against) the soil, and 3. the individual conducting the sample collection and the chroma production.

Soil chromatography is also a cross-sectional, intuitive, qualitative, ontological, and even poetic study of the here and now of the life of the soil. It was firstly invented by the Russian botanist Mikhail Tsvet (1872-1919) and later perfected within the studies and practice of biodynamical agriculture, more specifically by Rudolf Steiner and Ehrenfried Pfeiffer. Soil chromatography was later maintained by a couple in the Netherlands (Adri and Jaap Bakker) and, in the late 90's, Jairo Restrepo and Sebastiao Pinheiro (2015) learned from them and saw the potential of using the technique as an available method for soil analysis for the *campesinos* of the world, with an explicit intention to fight back the global takeover of agriculture and food production from corporate and industrial capital. In that sense, the present-day method and use of the technique is strongly based on the experiences of Latin American radical agroecologists, and now we can see countless examples of people in Europe and some in North America translating the work from

[72] Perhaps go touch some soil or drink a microbiologically enriched (fermented) drink.

Spanish[73] and picking up the trail. Our aspiration is to also contribute to this expansion to the Anglo-world and, why not, to soil geography.

We did the first chromas with soil samples collected in October 2020. Our learning method was a process of trial and error and learning by doing. Below we will go into more detail of the method, the process, and the reading of a chroma, with the interpretation that goes on when trying to learn from it to understand soil dynamics and use the lessons for practical purposes in the field. By the end, we also extend the project to the field of poetry and attempt a poetic reading of soil chromatography.

Without planning for it, chromatography resulted in being a perfect example to apply the theoretical and methodological tools we have exposed here: an intuitive and aesthetic approach to understand how life interacts within the soil in the creation of life. The chroma as a visual representation of life in its milieu. We hope to transmit what we have learned experientially during this process. If it can be summed up in one phrase: only life can generate life for the living.

After several months of learning about and doing chromatography on our own, following online tutorials and the only two publications we could find (Jairo Restrepo and Sebastiao Pinheiro 2015; Abad Santana 2014), we participated in a two-day workshop organized by several agroecologists in the vicinities of Otavalo, on the skirts of the Imbabura volcano. The workshop was guided by Francisco Abad, an agronomist who is also the main chromatographer in Ecuador, also a part of the growing network of young people following in the footsteps of Jairo Restrepo and Sebastiao Pinheiro in the revitalization of this very old technique. Francisco begins his workshop with the story of him learning from Jairo on a visit to his agronomy school in the University in Cuenca around 2012. Jairo came in and lashed out with his characteristic bombastic style on the corruptness of agribusiness brainwashing the minds of students and training them to be "agrotoxic prescribers." His relentless critique of the industrial and corporate cooptation of

[73] For some examples see (Kokornaczyk et al. 2017; Graciano et al. 2020; Nathaniel 2015; Medina-Saavedra et al. 2019; Lopez n.d.), also the websites https://www.permaculture.org.uk/articles/harvesting-sun-jairo-restrepo , http://www.ragmans.co.uk/shop/abc_of_organic_argriculture_/ http://www.regrarians.org/the-biofertilizer-manual-2nd-edition/

universities to the detriment of the way of life of the *campesino* is well documented in countless seminars around the world and are available online in public platforms.

Now we will describe the soil chromatography method as it was passed to us mainly from Jairo Restrepo, in his seminars and books, as well as from Francisco Abad, through his work, seminars, and voluntary and generous assistance through the process.

The method

After the hurdles of acquiring sodium hydroxide[74], NaOH, and finding the appropriate filter paper (Whatman paper grade No. 4 or No. 1), we managed to start the process. Collecting the sample is where it all begins. We always collect compound samples, that is, always take at least three sub samples from the area we are interested in and compound them in a single sample bag. For example, from one hectare pasture lots we are taking 7 samples in a zigzag or randomized pattern across the lot. The best way is to dig a V trench and then a small gardening shovel or a spoon to take the sample from the desired depth. Also, a machete is a useful tool if walking to distant places is required. There are professional tools, such as the earth auger, for gathering soil samples at different depths, but we prefer to use the tools anyone can find.

Image 15. Soil collecting with machete. Remove top vegetation and dig in a V to expose at least 15cm more than the desired collection depth. Photo by author.

[74] Because of its use in the manufacturing of cocaine, it is illegal to buy NaOH in Ecuador without a special permit issued by the Ministry of Defense and the Ministry of Agriculture. A policy by a state that believes that complicating access to a basic chemical will deter criminal organizations to get it through other sublegal means that thrive under these policies.

Image 16. Take samples from desired depth from the wall of the hole with a clean tool, directly into the collection bag. Repeat with all subsamples of the desired lot in the same collection bag. In the image we are collecting subsamples from two different depths. Photo by author.

The samples are placed in a labeled, plastic bag, mixing them thoroughly before placing them to dry in a low temperature (< 40°C) dehydrator, or at indirect sunlight. Soil is then immediately grinded and sifted for storage. This entire process takes 12 to 48 hours, depending on how long it takes from the soil collection to the dehydrator. Label everything. Date, place, depth, number of subsamples, at the very least. If the place and soil context are not familiar, then it is a good idea to annotate every observation of the collection site. However, in most places we collect samples from, we are familiarized with the climatic context, the color, texture, smell, and humidity of the soil, as well as the type of roots, flora, and soil macrofauna (worms and insects) we see at the desired depth.

For most horticultural soils or any sort of annual crops, we collect samples at 30 cm depth. For perennial crops with deeper roots, it is wise to go at least 40 or 50 cm. If we are interested in trees, either fruit or forest quality, it is ideal if you go at least 100 cm or even deeper. In a few cases we are interested in the entire soil profile, so we have gathered samples in the same plot at 30 cm, 50 cm, 80 cm, 170 cm, and 220 cm. It is intense work to dig a 2-meter hole, but the process is rewarding and worth doing at least once in a particular soil, even if from then on you can just continue to monitor changes at a more superficial depth. In some cases, we take the opportunity when we or someone else is digging for other purposes to collect deeper samples of a soil we are working with, or nearby. For example, we collected samples of varying depths during the construction of a water reservoir.

Image 17. Collecting samples at various depths during the construction of a water reservoir while enduring pouring rain. Photo by author.

Image 18. Drying samples in a low-heat dehydrator. We learned later that plain paper is more convenient than aluminum foil. Photo by author.

Image 19. Dried, grounded, and sifted compounded soil samples in labeled airtight plastic bags. Here we see three samples at three different depths of the same site. Photo by author.

While the samples dry, we prepare a 1% solution of NaOH. This is our solvent for the soil sample. To prepare one liter of solution, dissolve 10 g of NaOH in 1 liter of distilled water. We then prepare a dilution of 0.5 % silver nitrate, $AgNO_3$, by mixing 0.5 g of $AgNO_3$ with 100 ml of distilled water. This is the photo-sensitive solution to impregnate the filter papers and reveal the chromatographic image of the soil. To prepare the filter paper, we use the Whatman filter paper grade No.4 with 150 mm diameter. Find the center and carve a 2 mm hole. It is necessary to prepare a wick from another filter paper of the same quality: cut a 2 cm square and roll it into the hole in the middle of the filter paper. We mark spots at 4 cm and 6 cm from the center, as this will mark the limits of the impregnation of our sample. We mark the spots with a 2HB pencil, since the graphite does not interfere with the chromas or reveal on the paper. It is a material that is too heavy and not dissolved in NaOH, so it does not run on the paper. Using filter paper No.1 of 185 mm diameter is a bit more challenging, and dilutions need to be adjusted to run samples more appropriately in this paper. After some experimentation, the most convenient paper for fast analysis is No. 4 - 150 mm, but the most beautiful and detailed chromas are revealed using paper No. 1 - 185mm.

We now need to impregnate the filter paper with the $AgNO_3$ to make the soil solution that will run through it photosensitive and reveal the colors and patterns we are looking for. At this point, the room where we work is only illuminated by a red lightbulb. We place a small petri dish inside a larger petri dish, and we fill the small petri with the solution of 0.5 % $AgNO_3$. We then place the filter paper on top with the wick submerged in the solution, and we let it run all the way to our first mark of 4 cm. A small detail that we figured out after the first few rounds was that inevitably each chroma has an A-side and a B-side. The A-side is the side more exposed to the light, that which is facing you on the petri dish, the side you place the label with a 2HB pencil. This A-side has the most detail and is usually darker in tone. The B-side is lighter and more homogenous, as it has been less exposed to light.

Image 20. Impregnating filter papers with $AgNO_3$ solution. Photo by author.

Once the silver solution reaches the 4 cm mark, we remove them and leave the papers between two absorbing towels to dry in a dark box. While the impregnated papers are drying, we will dilute the soil sample with the 1 % NaOH solution. We mix 5g of the prepared sample with 50 ml of the 1 % NaOH solution in an Erlenmeyer flask, or baby food jar. There are some variations to this part of the process when dealing with samples much denser in mineral content such as andosols. Common in Ecuador, usually from the *páramos*, where soil minerals are incredibly rich, but soil metabolism is very slow due to high altitude. In these cases, instead of a 10 % dilution, 5 g of soil in 50 cc of solution, we go for a 5 % dilution by mixing only 2.5 g of soil with 50 ml of the NaOH solution. In some of these samples, we have even gone to 1.25 % dilution with 2.5 g of soil in 200 ml of solution. For liquid biofertilizers, or any sort of liquid samples, the process is slightly different[75].

Now begins the process of mixing the sample and adding the dynamization process, as this method has been developed and described to us. Moving in circular motions, we begin clockwise 7 turns, then counterclockwise 7 turns, and we repeat this process 7 times. Then we let the solution sit for 15 minutes and we repeat the process, letting it sit for 60 minutes. After 60 minutes we repeat this one last time and let it sit for 6 hours. 343 turns repeated 3 times.

---

[75] We will not go into details about this, since we explored and experimented on running, revealing, and analyzing chromas of things other than soil samples well after we had the soil chromatography method adjusted. We will just briefly share that the process has been extremely rewarding, but closer to an artistic expression than to any practical analysis, we have done chromas on different vegetable and fungal tissues, as well as cow and human milk, human placenta, cow rumen, and human feces comparing adult excrement and newborn meconium.

Image 21. The kitchen soil lab. Weighing and preparing soil samples for dilution and dynamization. Photo by author.

Now that we have our dry and prepared filter papers and soil solutions, we organize the same arrangement of petri dishes and fill the small petri dish with the supernatant carefully extracted with a syringe or a pipette taken without disturbing the solution. Usually no more than 5 to 10ml of supernatant is needed to fill the small petri dish. We place another wick, place the impregnated paper with the wick submerged, and let the soil sample run all the way to the 6cm mark on the filter paper.

Image 22. Running diluted soil samples on paper previously impregnated with $AgNO_3$. Photo by author.

Image 23. Rich and dark andosols of the Andes dissolved in various dilutions for testing. Photo by author.

Lab work is almost the stereotype of scientific work, and we are now reminded of why that is. It is especially important to keep a meticulous attention to detail, constant observation, registration, and careful movements that require precision so the observations and records can be more precise. Once we felt comfortable with the tools and equipment, everything ran smoothly, and could do over 50 samples simultaneously. We particularly enjoy extracting the supernatant from the flasks with a pipette of a syringe. The samples have been stirred 343 turns with 3 repetitions and are now still for over 6 hours. The sediment is clearly visible, and the rich deep color of the liquid is seductive. It feels like we are working with something valuable, precious, profound. Something pure, whatever that may mean, and definitely not in the literal meaning of the word.

Then the chromas are ready and need to be left to dry and revealed by progressively exposing them to indirect light. It can take a full day to dry and at least 3 days to fully reveal all the patterns and colors. For storing them, it is useful to submerge them in liquid paraffin wax and scan them, saving them in a folder protected from light.

Image 24. Revealed chromas drying from the paraffin wax cover before scanning and storing. Photo by author.

Describing a chroma: Zones, colors, patterns, transitions

A chroma is comprised of five sections: 1. central zone, 2. internal zone, 3. intermediate zone, 4. external zone, 5. peripheral zone. The reading of the chroma also takes place in five steps. It includes an analysis of the 4 zones of the chroma proper (zones 1 to 4) and an integral read of the integration or transition of all the zones. The central zone represents the most mechanical part of the soil, the structure, its aeration, and water holding capacity. Zone 2 is where the heaviest molecules stay, closer to the center, comprised of mostly heavier mineral components. We call this the mineral zone. Zone 3 is where organic molecules stay, also called the organic matter zone. Zone 4 is where the lightest molecules go, farthest from the center, mostly protein material. We call this the enzymatic zone, or metabolic zone. The exterior of the chroma is free from solution and it is used for handling and labeling the chroma.

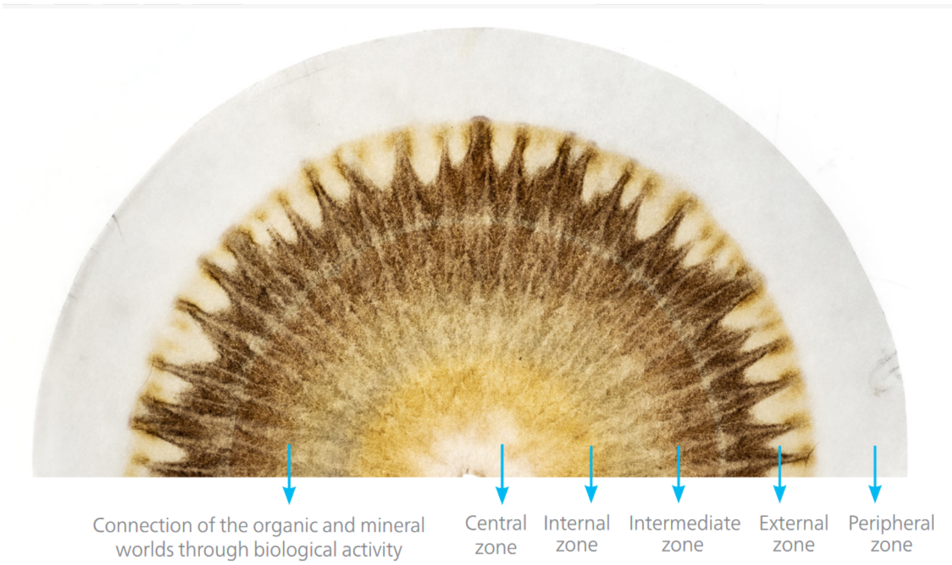


Figure 3. Chroma by the author, zone references obtained from Jairo Restrepo and Sebastiao Pinheiro 2015, 57.

What we are looking for in the chromas are basically four aspects: size (in relation or proportion to the entirety of the chroma and to the other layers), colors, patterns, and transitions among the different zones. On size, there is not much to see, except when a zone is predominantly larger or smaller in proportion to the other zones. On the other aspects, there is not an ideal combination, but what we look for, generally speaking, is that there is a set of "desirable characteristics" and others that are "undesirable." The key part of reading a chroma lies in an integral reading of all the zones, aspects, and characteristics as a whole. The only way to make sense of a particular chroma is if you have a context in mind. A context that involves what has happened and is happening to the soil around the time of the collection of the sample. The key things we account for are the depth, the type of crop or covering of the soil, climatic conditions at the time of collection, and particular interventions that the soil has been exposed to. These can be the addition of soluble fertilizers, biofertilizers, composts, herbicides and other agrotoxics, mechanization such as tillage or plows, animal grazing, and anything else that might be relevant that can affect the condition of the soil at the moment when we took the sample.

Desirable colors, meaning colors that indicate a healthy soil, are everything that falls under the yellow, golden, brown, orange, reddish or rusty, or anything on the ocher scale. Undesirable colors are black, gray, blue, purple, or dark green colors. See, for instance, the colors of this chroma coming from an undisturbed Amazonian soil and compare it to the soil of a plot of beans and corn using heavy mechanization, herbicides and agrotoxics, including soluble fertilizers.

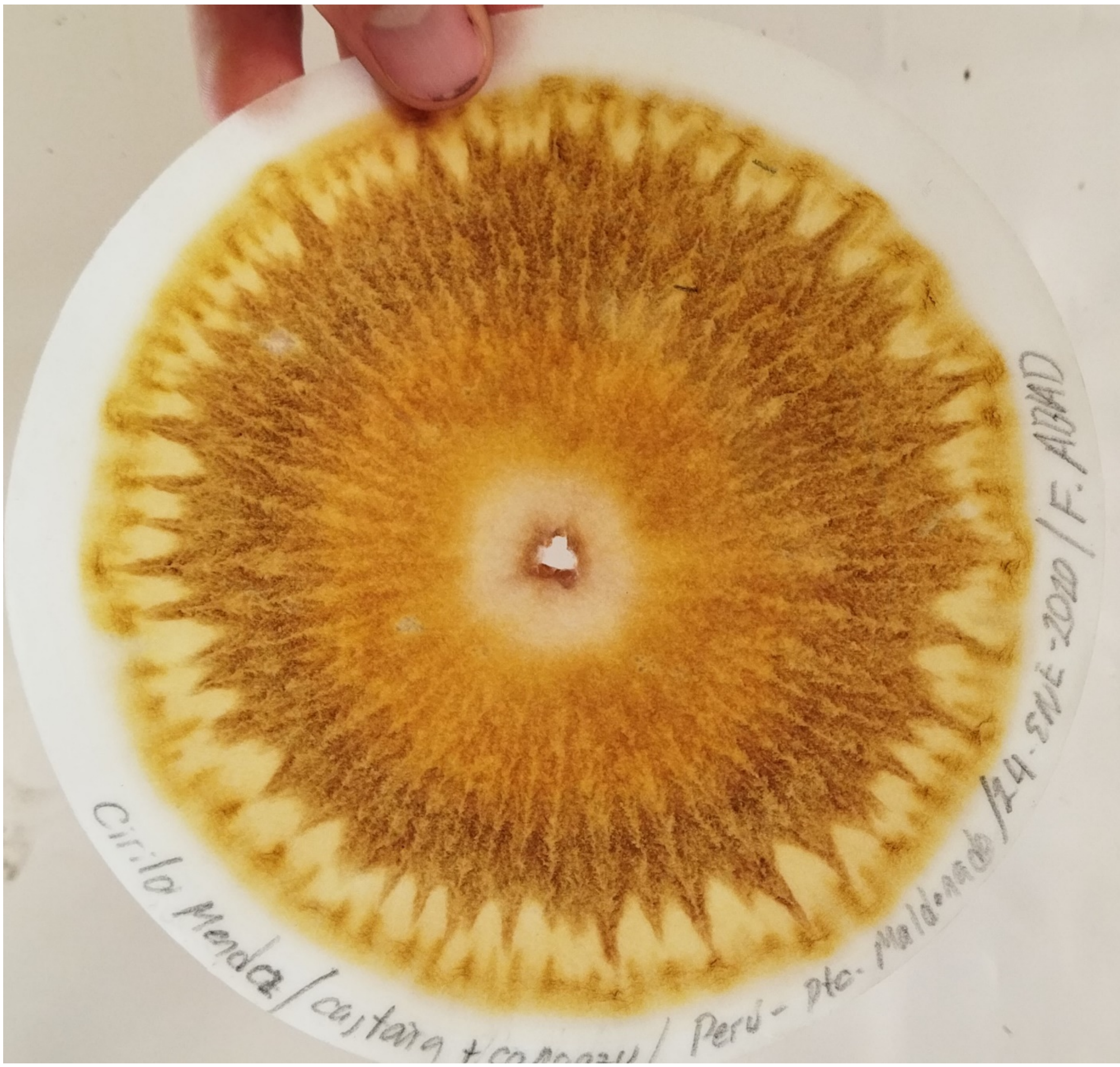


Image 25. Note the colors and general tones of this chroma from a forested soil bordering undisturbed Amazonian Forest. Castaña, Pto Maldonado, Perú. Chroma by Francisco Abad, photographed by the author.

Image 26. Compare colors and tones of the previous chroma with this one from a heavily mechanized soil that has received extensive herbicides, fungicides, and soluble fertilizers in a corn field in the suburbs of Quito. Corn and beans, Puembo, Pichincha. Photo by author.

Patterns that are desirable are evenly radiating shapes, mesh-like patterns, and tunnel-like plumes that irradiate from the center to the periphery. The plumes are an important part of the patterns and we pay attention to how they radiate, how visible are they, and very importantly how they terminate towards the limit of zone 3 and within zone 4. The terminations that are desirable are almost like narrow teeth, with the plumes reaching all the way to the periphery. At the tip, a volcano-like figure is a very good sign for zone 4, a triangle with a diffused inverted triangle over it. Almost like a volcano with an eruption cloud above it.

As for transitions, the most subtle and gradual change between zones makes for the most desirable pattern. A drastic borderline across zones or a clear distinction of colors or shapes is not desirable. That is why plumes are a key element. The more visible they are, the more they allow for a subtle transition across zones. This continuity shows that all the elements in the soil are integrated and related to each other. Minerals being transformed by microorganisms in organic matter into enzymatic and metabolic components, so to speak. There can be a rich mineral layer, but if there is no microbiome to chelate and transform the mineral holdings of a soil, the minerals will stay "trapped" in forms that are unusable by the living organisms (plants, fungi, and other microorganisms).

On the interpretation and value of soil chromatography

It is important to insist on the aesthetic nature of the interpretation of chromas. It is quite different to a quantitative soil analysis where the analysis brings out numbers and percentages of soil components. For instance, in a quantitative soil analysis, from the physical perspective we receive the classic classification of soils by their percentage of sand, clay, or loam—basically an analysis of the size and structure of particles. We obtain a percentage amount of organic matter, and a numbering of elements identified in their detectable molecules. For instance, N is commonly detected as NO_3 or NH_4 and P as PO_4. These analyses emphasize the main macroelements (NPK) and a few microelements, depending on the type of crop being analyzed and how much you are willing to pay. In the case of pastures, for instance, they pay attention to S, Mg, Ca and, sometimes, if you are willing to pay even more, Mn, Fe, Zn, B.

We do not neglect the usefulness of this quantitative analysis, as we use them routinely in parallel to our chromatographic analysis. They are particularly useful to demonstrate to agronomists, neighbors, and our collaborators that the work we are doing by biofertilization with an emphasis on enhancing soil relations has measurable results. For example, see the following figures of quantitative soil analysis of the same pasture lot at almost two-year intervals. After two years of fertilizing with fermented mineralized manure biofertilizers, sulphate-based broths, and microbiological enhanced composts, we have achieved significant increases in organic matter content (6% to 10.7%) and amending any mineral deficiencies in both macro and micronutrients. These results are supposedly, according to conventional agronomists that advocate for the use of soluble fertilizers, as impossible using "organic" agriculture, yet the results are visible. Other parameters of success involve increasing the days of grazing rotation (number of days that the pasture has to recover from one grazing to the next) from 27 days to over 35 days without reducing the number of animals, meaning that there is more food on the pasture; as well as significant increases in milk production.

RESULTADOS

Código Agrarprojekt: GEG-020921

INFORMACIÓN DE LAS MUESTRAS	
Tipo de Muestra:	Suelo
Cultivo:	Pastos
Número de Muestra:	# 1
Información Proporcionada por el Cliente:	Muestra de Suelo

Contenido de macro- y microelementos en mg / kg de suelo seco

	Análisis	Unidades	*Método de Extracción	*Niveles Óptimos para Pastos - Cultivo Intensivo	Resultado
Características del Suelo	Materia Orgánica	%	-	5 - 15	6,0
	Conductividad (CE)	mS/cm	Vol. 1:2	0,2 - 0,5	0,07
	pH (en H_2O)	-	Vol. 1:2	-	7,1
	pH (en KCl)	-	Vol. 1:2	5,5 - 7,5	6,1
Macronutrientes	Nitrato (NO_3-N)	mg/kg	Extracto Agua	-	3,7
	Amonio (NH_4-N)	mg/kg	NaCl 0.05 M	-	3,1
	(NO_3+NH_4)-N	mg/kg	-	30 - 50	6,8
	Fósforo (P)	mg/kg	$NaHCO_3$ 0.5M	20 - 35	19,9
	Potasio (K)	mg/kg	NaCl 0.05 M	125 - 250	111
	Magnesio (Mg)	mg/kg	NaCl 0.05 M	45 - 90	180
	Calcio (Ca)	mg/kg	NaCl 0.05 M	400 - 1200	298
	Azufre (SO_4-S)	mg/kg	Extracto Agua	10 - 20	3,1
Micronutrientes	Hierro (Fe)	mg/kg	DTPA/$CaCl_2$	20 - 50	56,0
	Manganeso (Mn)	mg/kg	DTPA/$CaCl_2$	4 - 20	28,5
	Cobre (Cu)	mg/kg	DTPA/$CaCl_2$	1,3 - 5,0	3,6
	Zinc (Zn)	mg/kg	DTPA/$CaCl_2$	2,5 - 10	2,3
	Boro (B)	mg/kg	Extracto Agua	0,15 - 0,60	0,17
Peligro de Salinidad	Sodio (Na)	mg/kg	Extracto Agua	< 140	10,8
	Cloruro (Cl^-)	mg/kg	Extracto Agua	< 210	7,8
	Sales Totales	mg/kg	Extracto Agua	< 2000	60,0

* Fuente: Soil Science Society of America Inc. (Ed.). 2001. Methods of Soil Analysis. 1390 pp.
 - = No Aplica
Nota: - Los datos y resultados están basados en la información y muestras entregadas por el cliente para quien se ha realizado este informe de este informe de manera exclusiva y confidencial.
- La fecha de ensayo y los métodos utilizados estan a disposición del cliente cuando lo requiera.
- El Laboratorio no realizó el muestreo por lo tanto no certifica el origen de las muestras.
- Prohibida la reproducción total o parcial de Los resultados. No procede copia.

Figure 4. Quantitative soil analysis of pasture Santa Cristina September 2021.

RESULTADOS

Código Agrarprojekt: GEG-180223 **Pág 2/2**

INFORMACIÓN DE LAS MUESTRAS		
Información Adicional:	Hda. La María	
Tipo de Muestra:	Suelo	
Cultivo:	Pastos (Rye Grass)	
Número de Muestra:	# 1	# 2
Información Proporcionada por el Cliente:	Lote Sta. Cristina	Lote San Esteban

Contenido de macro- y microelementos en mg / kg de suelo seco

	Análisis	Unidad	*Método de Extracción	*Niveles Óptimos para Pastos - Cultivo Intensivo	Resultado	Resultado
Características del Suelo	Materia Orgánica	%	-	5 - 15	10,7	11,0
	Conductividad (CE)	mS/cm	Vol. 1:2	0,2 - 0,5	0,12	0,12
	pH (en H_2O)	-	Vol. 1:2	-	7,0	6,6
	pH (en KCl)	-	Vol. 1:2	5,5 - 7,5	6,1	5,7
Macronutrientes	Nitrato (NO_3-N)	mg/kg	Extracto Agua	-	6,1	7,2
	Amonio (NH_4-N)	mg/kg	NaCl 0.05 M	-	16,1	13,7
	(NO_3+NH_4)-N	mg/kg	-	30 - 50	22,2	20,9
	Fósforo (P)	mg/kg	$NaHCO_3$ 0.5M	20 - 35	53,1	37,7
	Potasio (K)	mg/kg	NaCl 0.05 M	125 - 250	161	170
	Magnesio (Mg)	mg/kg	NaCl 0.05 M	45 - 90	220	204
	Calcio (Ca)	mg/kg	NaCl 0.05 M	400 - 1200	380	335
	Azufre (SO_4-S)	mg/kg	Extracto Agua	10 - 20	6,0	6,5
Micronutrientes	Hierro (Fe)	mg/kg	DTPA/$CaCl_2$	20 - 50	342	585
	Manganeso (Mn)	mg/kg	DTPA/$CaCl_2$	4 - 20	54,5	29,7
	Cobre (Cu)	mg/kg	DTPA/$CaCl_2$	1,3 - 5,0	4,7	4,9
	Zinc (Zn)	mg/kg	DTPA/$CaCl_2$	2,5 - 10	12,1	14,6
	Boro (B)	mg/kg	Extracto Agua	0,15 - 0,60	0,34	0,26
Peligro de Salinidad	Sodio (Na)	mg/kg	Extracto Agua	< 140	9,0	8,0
	Cloruro (Cl^-)	mg/kg	Extracto Agua	< 210	6,1	8,3
	Sales Totales	mg/kg	Extracto Agua	< 2000	98,3	102

* Fuente: Soil Science Society of America Inc. (Ed.). 2001. Methods of Soil Analysis. 1390 pp.
 - = No Aplica
Nota: - Los datos y resultados están basados en la información y muestras entregadas por el cliente para quien se ha realizado este informe de manera exclusiva y confidencial.
- La fecha de ensayo y los métodos utilizados estan a disposición del cliente cuando lo requiera.
- El Laboratorio no realizó el muestreo por lo tanto no certifica el origen de las muestras.
- Prohibida la reproducción total o parcial de los resultados. No procede copia.

Figure 5. Qualitative soil analysis of pasture Santa Cristina (left column) and San Esteban (right column) February 2023.

The nature of how you define a problem, or a question, determines implicitly how the solution will be presented. In this case, if a deficiency in a particular element is identified, then the solution is straightforward: add such element to an available (soluble) source to cover such deficiency. As Pancho Abad mentioned in his workshops, agronomists go through years of training to be able to do a cross-multiplication operation so that they can provide a scientific solution to tell farmers how much fertilizer to buy. Worthy to note, but an unnecessary explanation to the keen observer, is that these quantitative soil analyses are presented in such a way that the solutions or actions derived from such analysis come in a packaged form based on the available commercial formulas of soluble fertilizers. The industry presents you with a diagnosable problem that can be easily fixed by the products they sell.

The weakness of such analysis is that it is a quantitative detection of individual elements, and the interpretation required to understand how they relate to each other within the living soil structure is up to the agronomist. Whoever is reading these results decides based on the referential amounts if your soil is deficient or has an excess of a particular element. How the referential amounts are determined is yet another conversation that few pay attention to. Little or nothing is presented in such analysis as to how these elements relate to one another. As we have seen in the discussion of healthy soil physiology, elements do not act individually. How one element works impacts how another element works within soil microbiology or plants. Another observation that quantitative soil analysis disregards is that soil is not a sum of individual elements in their chemically detectable forms. These elements are part of a physiology of life that involves the wide diversity of microbiology that moves and transforms elements into the compounds that plants take in for their own processes.

What chromatography offers is a glimpse into the relations of soil processes at the time of their sample. How does microbiology within organic matter interact with mineral reserves in the soil; what is the diversity of mineral components that are available to both plants and microorganisms; how is the physical composition of the soil affecting the water and air holding capacities of the soil, also known as soil structure; and how are the enzymatic and proteic processes occurring at a molecular level across soil life.

Such particularities of the living soil's dynamics evidence the futility of making any definite conclusions of the results of a singular chroma, for two main reasons. The first one is because there is no such thing as a "reference" chroma. Some chromas may be more desirable for a particular crop or region, but there is no perfect chroma out there to compare to. We can use, for instance, the chroma of the “undisturbed” Amazonian soil or perhaps some of the soils we have taken from healthy Andean forests. If there is a referential chroma at all, we would point to a chroma of a healthy forest soil, but even that is specific to its region, latitude, climate, and a huge etc. that makes it irreplaceable anywhere else. In another sense, something similar can be said for quantitative soil analysis; a soil sample taken on a particular day will never be the same as the same soil sampled on a different day. Issues such as climate characteristics, humidity, temperature, wind, and countless factors that are part of an open system such as a plot of soil need to be accounted for, or at the very least acknowledged.

We have witnessed that even the same soil sample, processed in two different flasks by the same person using the same standard process, produces different chromas. Chromatographers emphasize the energetic or biodynamic aspect of the process by stressing the fact that even the way two people sample the soil and mix the samples produces different chromas, since the energies instilled into the dilutions are not the same. This is something that has been hard to grasp for a scientific mind such as our own, and even harder to try to explain. Let us use a visual example. The following two pairs of chromas are the same sample, the same dilution from the same container, and impregnated at the same time. In short, everything has been the same except that they were revealed in two different papers. And they are not the same. If you compare them to other chromas from other samples, you can tell that these two are similar enough for us to tell that they come from the same sample, but they are not identical. One shows some patterns or colors more clearly than the other, but their general appearance is similar.

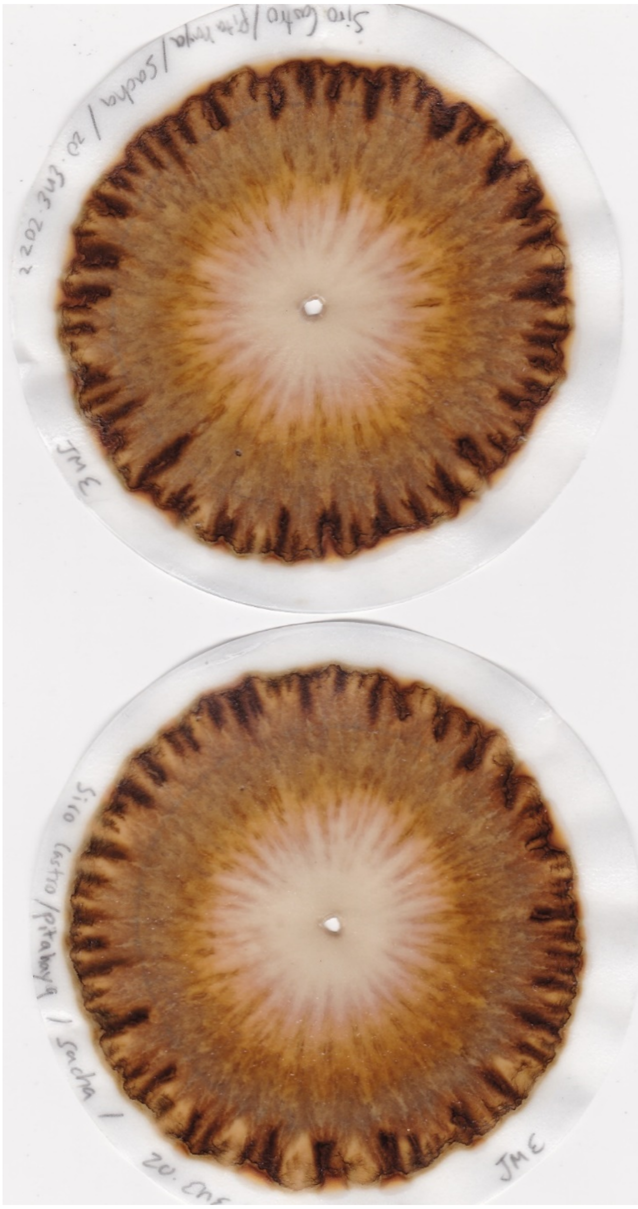


Image 27. Pair of chromas of the same sample, run simultaneously on two separate papers. Conventional cultivation with fertilization using biofertilizers, microorganisms, and mineral broths. Pitahaya, Joya de los Sachas, Orellana.

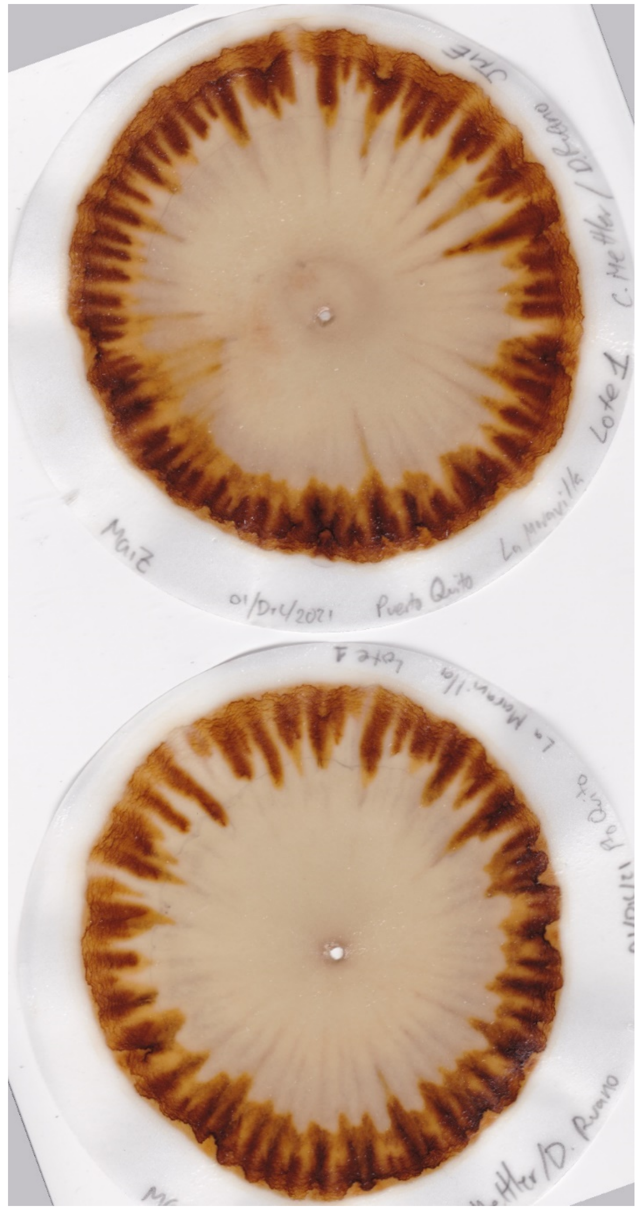


Image 28. Pair of chromas of the same sample, run simultaneously on two separate papers. Conventional cultivation, extensive tillage, application of herbicides, fungicides, and bactericides. Corn, Puerto Quito, Pichincha.

This realization has convinced us of the importance of always running at least two chromas of every sample dilution. Sometimes we will choose one over the other since it shows the characteristics we observe more clearly. We believe, understanding the interpretative and incomplete nature of this analysis, that this fact of always having unique chromas does not reduce or diminish the utility or the relevance of such analysis. Instead, it adds a texturized interpretation of the analyzed soil that matches the philosophical basis of our method: a situated and knowingly incomplete description of material reality that does not attempt to provide a totalizing truth from an open system that has more unknown than known factors. It is easy to understand why Jairo Restrepo aligns chromatography analysis with a type of soil poetry, an art. We intend to take his challenge seriously.

The second reason as to why it is futile to make any definite conclusions from a single chroma is its temporal nature. The analysis is transversal in space and time, it provides us with a point in time and space of the soil we are sampling, and therefore a single point in this spectrum is only something closer to a form of pure plastic artform, not something we can use for getting to know our soils and our interventions on the soil. The usefulness of soil chromatography lies in the creation of a temporal analysis of a series of chromas across different seasons and moments. In the case of pastures, we think the ideal method would be to take an analysis of the soil just before or right after animals come to graze (harvest time) and do this for every cycle of grazing. For example, the contrast of our two main sampling sites: in La Maria, this cycle is close to 30 days; in Los Alpes, it ranges from 60 to 90 days. The practicality and cost of this frequency makes it hard to achieve, so we have aimed for at least two samples a year: one during the wet rainy season (a.k.a. winter) and one during the dry season (a.k.a. summer). Perhaps more ideally would be to take four samples a year, since even though we are in an equatorial two seasons region, the mundane and cosmic energies of the four seasons are still in play even if they are subtle enough to be hard to perceive.

Additionally, we have been focusing on taking samples from two kinds of plots. The first ones are plots that have good characteristics and provide us with a reference to what we consider a desirable plot, something measurable qualitatively by the look and feel of the grassland but also quantitatively by the amount of milk that is produced when the herd grazes from such pastures. The second ones are the problematic or troublesome plots, those with undesirable characteristics of the grasslands, delayed or strange growth, and lower milk production. It is on these types of plots that we also conduct quantitative soil analysis, and in the process of reading both types of analysis we devise interventions and strategies to make improvements. Chromatography here brings out its main usefulness: to evidence change across time and, most especially, after particular interventions.

A few observations on three chromas.

Taken the same day, but with a difference in the stages of pasture. All of them within 15 days of being grazed. All of them have no till pasture management, grazed using the Voisin method for rational-rotational grazing, fertilized using manure and grass composts, bokashi composts, and mineralized fermented manure liquid fertilizers. Soluble fertilization no more than once per year, and no use of herbicides or agrotoxics of any kind for over 20 years. The samples are named based on the names of the pastures in La Maria[76]: San Martín, La Esperanza, and Santa Inés.

[76] We will give some description of this place, called La Maria, in section 3.3.

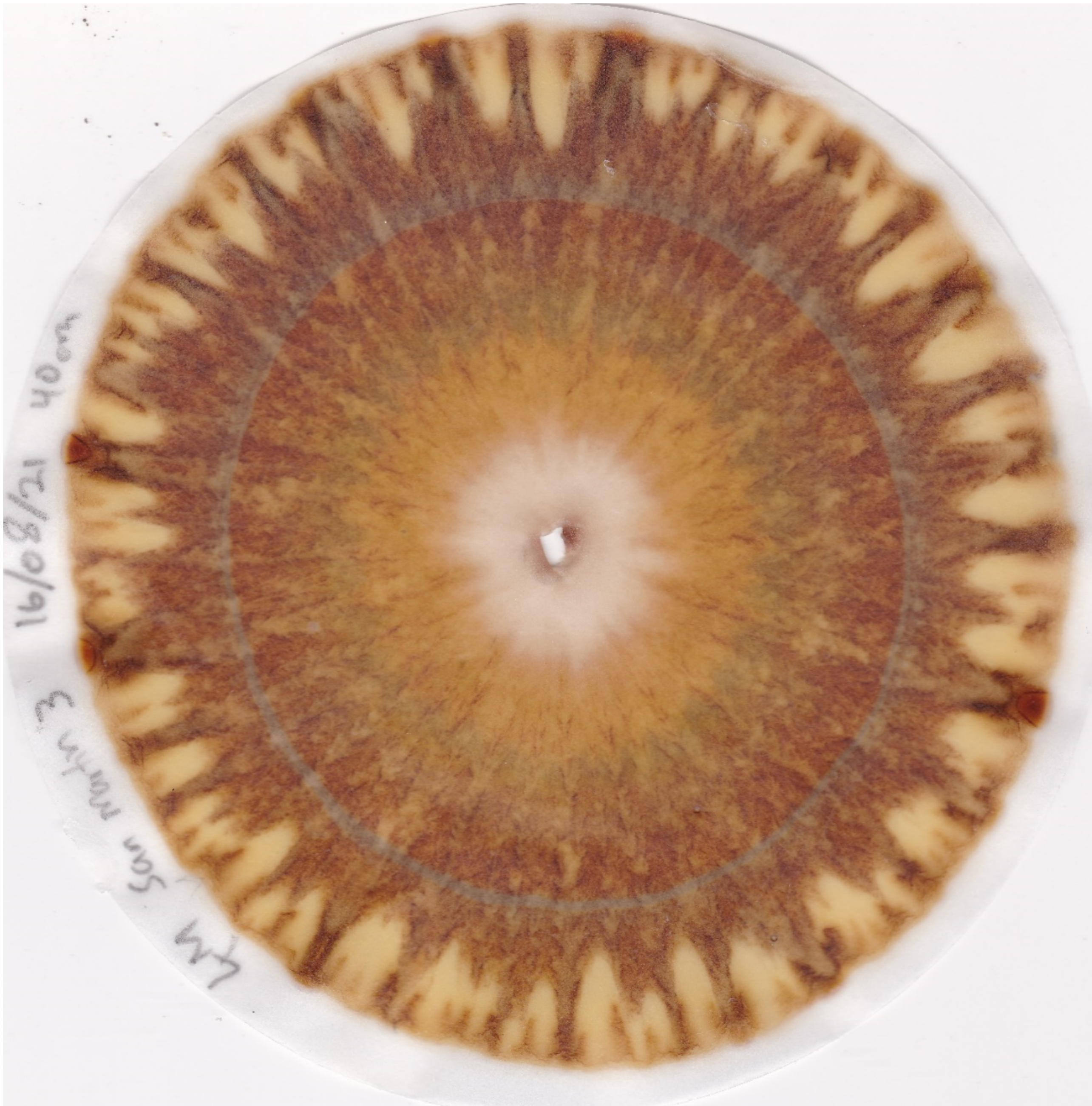


Image 29. Pasture, San Martín, La María, Machachi.

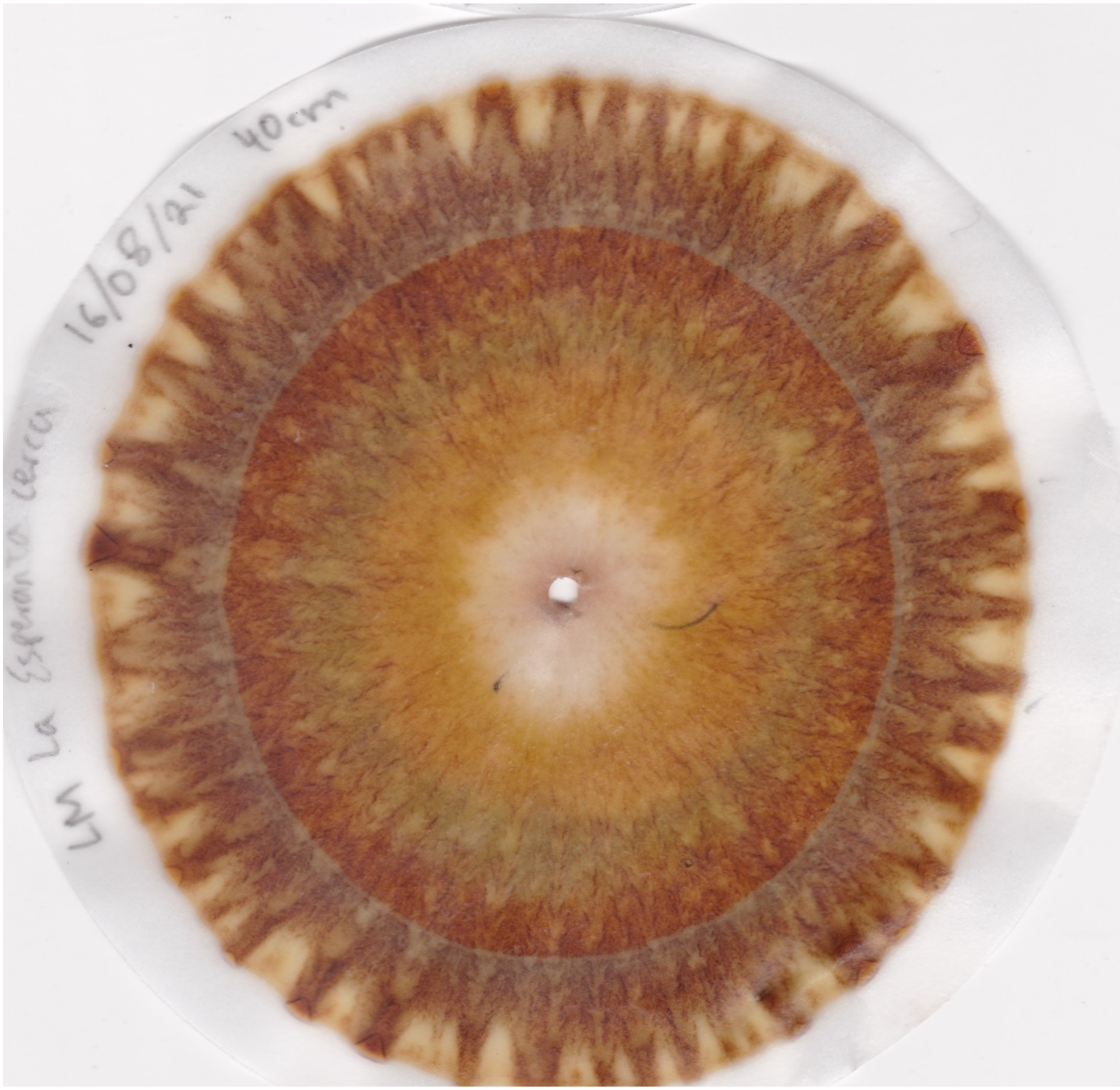


Image 30. Pasture, La Esperanza, La María, Machachi.

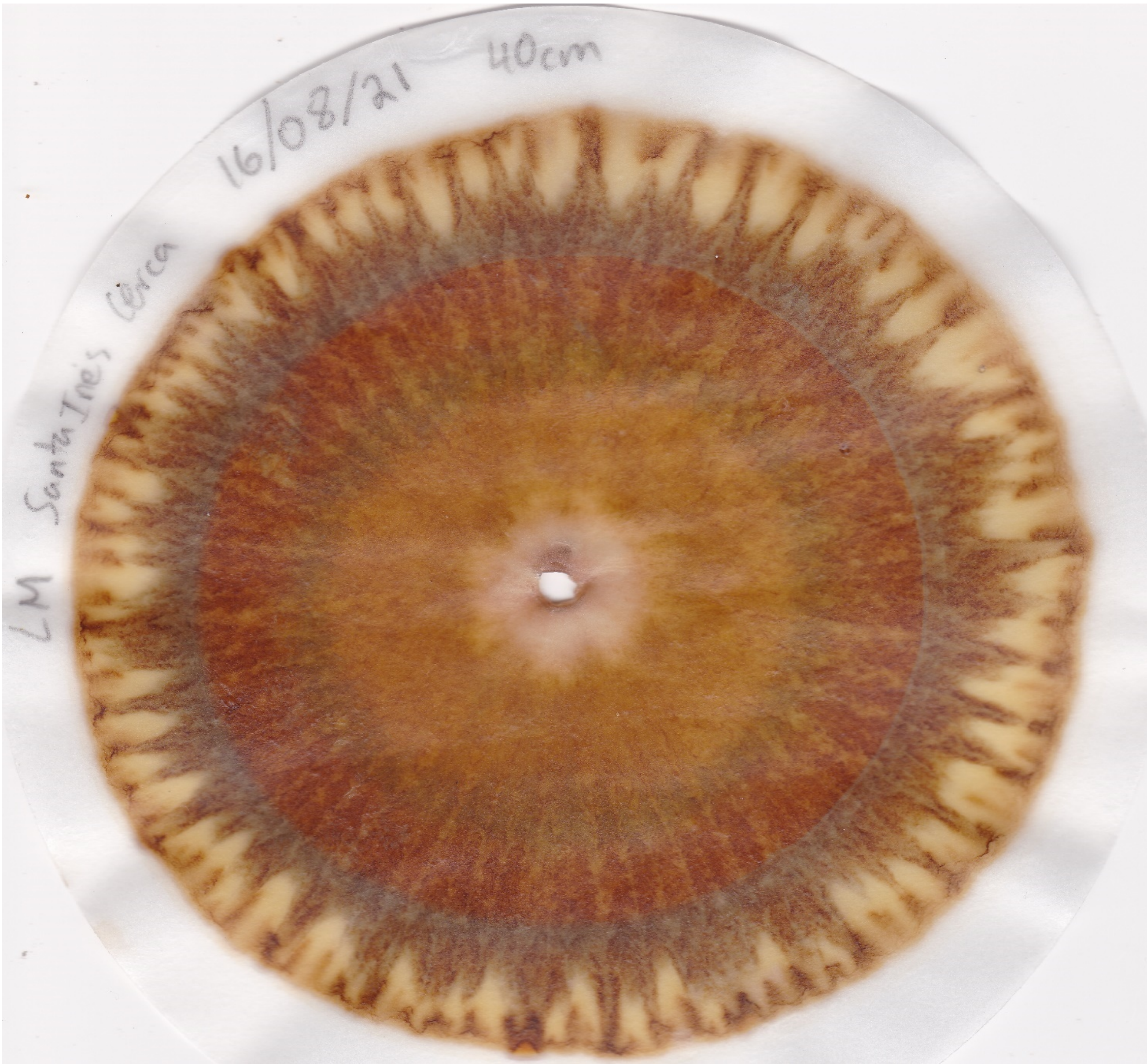


Image 31. Pasture, Santa Inés, La María, Machachi.

All have a good central zone, light beige in color. San Martín being the larger one and Santa Inés being the smaller one. Integration into zone 1 is better in Martín, going from brown/pink into a dark gold where plumes have begun to show. Zone 1 in Martín is homogenous in color with a perfect transition to a thin greenish to blueish color. Inés and Esperanza central zones change to a dark gold very thin with later changes into lighter gold. Zone 1 in both Inés and Esperanza has these two golden tonalities and not many plumes visible. Zone 1 in both seems larger than in Martín and then transitions into an even thinner greenish layer. Plumes here are visible in

Esperanza and a bit less in Inés. Zone 2 transitions similarly in all; the green layer changes to light very subtle blueish into a brown rusty-colored layer beginning zone 2. In all three chromas, zone 2 begins close to the 4 cm mark. Plumes here visible to all, good shape, spear-like feathers crossing zones 2 and 3 all the way to the limit. Then a darker gray-blue layer changes color immediately but no plume dissipation. This layer is thinner in Martín and thicker in Inés, and in all fades into darker brown that plumes into the exterior zone. Fading here clearer in Inés and almost imperceptible in Martín. Exterior layer with light creamy yellow coloring, finishing plumes deep brown integrated to zone 2 plumes. Clearer teeth-like spaces on Martín and thinner on Esperanza. Orange, rusty water droplets on the terminations are visible in all, larger and more prominent on Martín, similar on the other two.

Mainly due to the subtle and more harmonic integration of the central zone into the intensely visible colors of zones 1 and 2, Martín is the most attractive chroma of the three, the exterior zone is also more complex and vivid with well-defined droplets at the tips of the plumes. In general, all three of them confirm the pattern visible in the soil of La Maria. A well-set combination of healthy organic matter with a richness in mineral diversity, visible in the richness of the colors in zones 1 and 2, the plumes are subtle but clear. The main weakness lies in the enzymatic integration of the mineral layer and MO activity to work the organic matter in the creation of a more stable structure and water holding capacity visible in the central zone. This points to a direct actionable strategy: more microbiology! We need to increase microbiological activity by increasing organic matter content and discharges of microbiologically enriched fertilizers. The methods to do that are detailed in section 3.3.

The beach chroma

A sample was taken from the beach within the city of Bahia de Caráquez, a few meters below the edge of high tide sand.

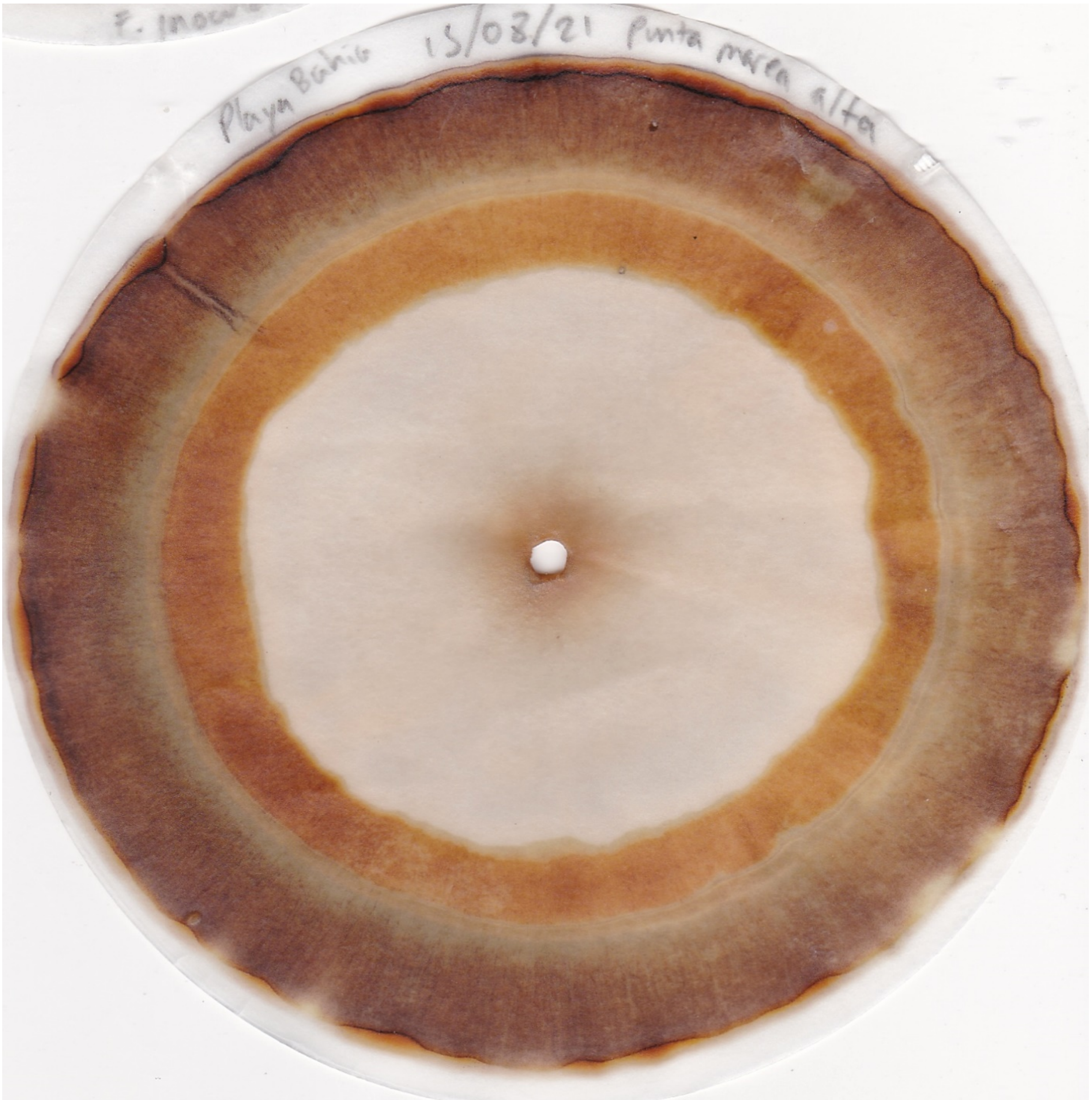


Image 32. Urban beach sand. Bahía de Caráquez, Manabí.

This chroma shows a huge central zone, all the way to the 4 cm mark. Its center is darker rusty and immediately fades into a light creamy white and homogeneous color. Drastically shifting to a thin rose pinkish layer with regular but uneven ends. No plumes are visible at all in the chroma. This layer may be the only zone 1 layer, or it may be altogether absent, and it is a part of a large zone 2. Hard to tell. This layer is thin and covered by a perfectly even thin line of gray and yellow mark followed by a thick layer of light purple that expands to the exterior, with some fading of colors from yellow to gray line but no fading of the border. The exterior layer is touching with a visible watery zone of dark orange color. Usually called by us droplets at the end of plumes, but here they are more like ponds in the absence of plumes or teeth-like structures. No zone 3 is visible except for these ponds lying right next to the wide purple layer.

Central zone as expected, large humidity and water holding, but porous and sandy, with an absence of organic matter, and almost no visible presence of MO activity to be able to integrate or transform the mineral layer. This seems to be the main layer of this kind of soil, and the homogeneity shows that it may be less diverse in mineral content. Mainly silicon, we speculate. Surprisingly, there is evidence of metabolic activity as shown in the periphery. In this case, it may be that life is taking place mainly "above" the soil than "below" it. Above as in all around it, and not within it. So much we do not know about the ocean.

ENCOUNTER 8 – AN EARTHWORM AT THE BEACH

Today we saw an earthworm in the beach sand. It was burrowed within the compacted sand that high tide washes over, but there it was. It was red and very thin, way thinner than a red earthworm as we've seen them, but it was stretched out and was almost 20cm long. Our son discovered it, and since he knows cuicas from our house and compost piles, he tried to grab it, but was shocked as we were when recognizing the surprising length and mobility of this strange creature. We wondered how this creature survives the salinity of the water or the coarseness of the sand? Dune… And another is that we must assume that it consumes organic matter of some kind, but at this point in the sand the organic matter is constantly being washed away. So, dependable organic matter must be in the water itself. Perhaps the inner workings of the beach to bring back the mangrove. Crabs have returned to the beach that we've been coming for years, but probably will be gone again when the beach is again full of humans (this is happening during covid 19 lockdowns). We saw one crab fighting for its life against a very noisy bird. It's a bird from the "cuco" or cuckoo family, a beachrunner. Migratory birds that may also be recent or passing visitors here. Will the worms stay as well? We can see the work of the crab with its digging and burrowing constantly on the wet sand, and the countless other mollusks, their work with the worms and other burrowers may give a chance for the countless seeds of mangrove washed form the few protected islands up the delta of the Chone. The mangrove is at the gate, waiting for us to stop closing it.

An aesthetic reading of an aesthetic object

Up to this point, the chroma has been described as an aesthetic object because it is an image with colors, shapes, and patterns. The whole purpose of revealing this object is to produce an analysis that might tell us something about the life, health, and general characteristics of a particular soil. Thus, chromatography is ultimately a soil analysis, an aesthetic analysis of the soil. As we reach the limits and end purpose of the chroma, we are now compelled to explore new ways of making this reading.

Describing and interpreting a chroma poses a problem or series of questions we have not yet tackled. Since the chroma is an image of an overly complex object, the soil, whose ontology – mostly based on networks, families, and sets – impedes any simplification or atomization, it follows that the description and analysis of this image can never be complete. There is certainly a leap between the image and our descriptive analysis, a wound that cannot be smoothed out. At the same time, there is also a leap between the soil and the chroma inasmuch as the chroma attempts to simplify the ontological complexity of the soil by translating it to shapes, colors, and patterns.

These series of leaps are rendered by the ending purpose of chromatography – reading the soil – and thus the entire process is tainted by the ontology of the soil, which impedes simplification. Modifying our view on chromas might give us a new way of approaching not only the method of chromatography itself but also its constitutive agents: the soil, the environment, the *campesinos*. What if we modify the purpose of the chroma? What if we take it out from the series of methodological steps for soil analysis and consider it as an object in itself that might (or not) render the beginning of another series of steps? What would it mean to consider a chroma separately?

No object can be taken in a complete vacuum, not even an artwork. Every entity pays tribute to a network of objects, a context, and a history. In this sense, the soil chroma pays homage to a (political or emancipatory) technique elaborated throughout decades. It relates to the earth (and its surrounding circumstances) as it is composed of it, and in itself is a network of individual chromas that give rise to the general idea of what a chroma is. The soil chroma can be stripped of its purpose of being an analysis of the soil, but it cannot forget the essential components that originated the chroma. Without them, the chroma could not be identified; it would be some other thing.

The German philosopher Martin Heidegger at this point is relevant. When speaking about the work of art, he describes it as this special object that has the same role as truth. For Heidegger (2008, 182), truth is an unconcealment that, in the context of the work of art, occurs between the earth (the matter) and the world (the network of the activities of the living). In its unconcealing nature, truth is not pure illumination, but it is also non-truth because it keeps what is concealed or hidden. The earth, in its utter complexity and ungraspability, is what is hidden, and it is brought to light by the truth. Inasmuch as the earth is material, truth needs to occur in a concrete place, and the work of art is this place that opens up the possibility for truth (or unconcealment) to settle.

It would seem that a chroma could be this place of truth where the earth is unconcealed and turned into world. A chroma might not be an object in a museum or gallery, but it certainly is an object that is used by the *campesinos* of the world and that it forms part of a culture with its particular practices. The work of art, however, is not there to be used but to be this place of openness. Its "function" is merely to exist, and its existence is dependent on the people who preserve such work. In order to preserve, it is not enough to look at or use an object, it requires a certain knowledge: "Preserving the work means standing within the openness of beings that happens in the work. This 'standing-within' of preservation, however, is a knowing. Yet knowing does not consist in mere information and notions about something. He who truly knows beings knows what he wills to do in the midst of them" (Heidegger 2008, 192).

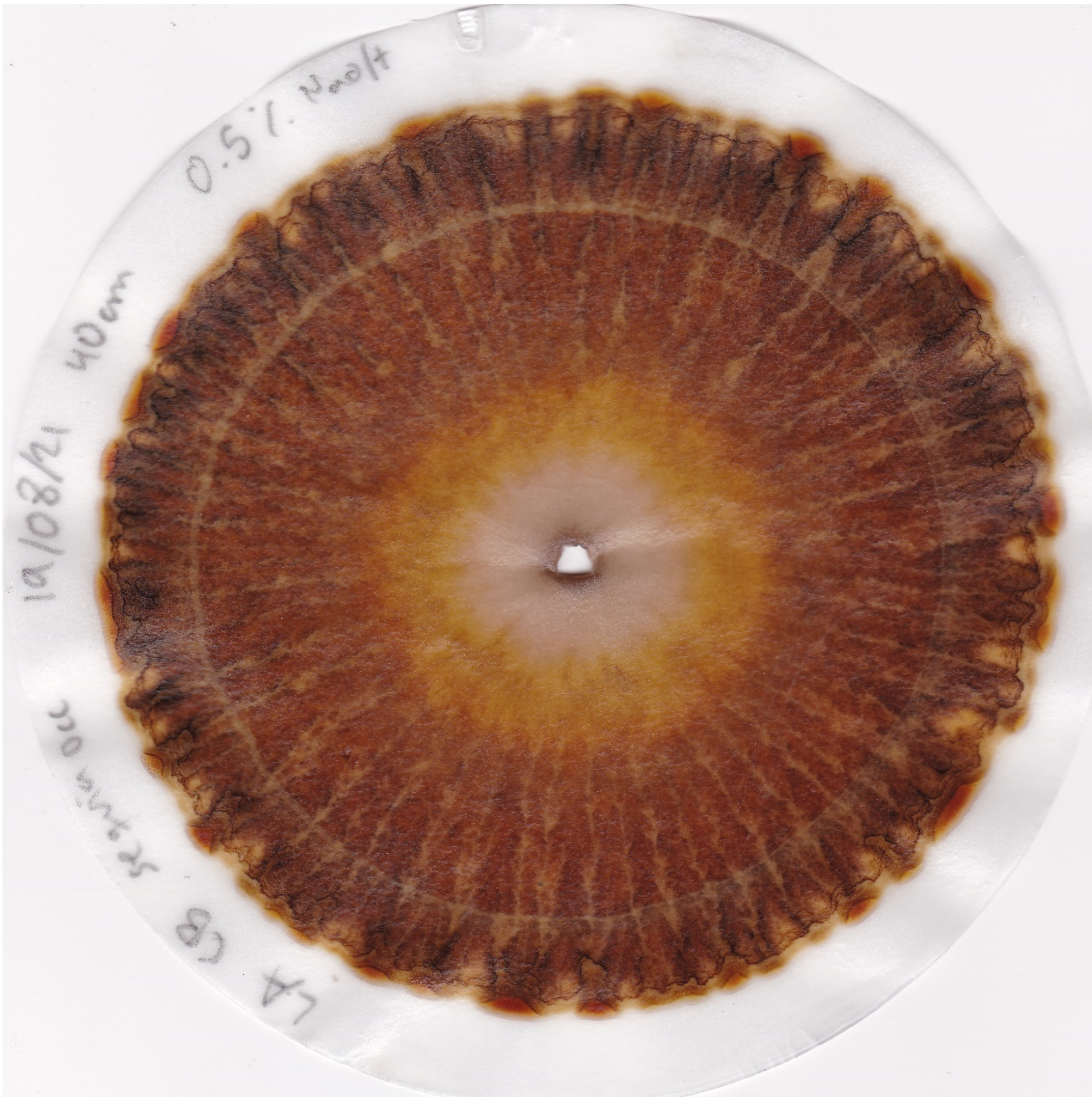
Knowing what to do in the midst of chromas is an unending task because its interpretation is aesthetic and incomplete, but there is certainly a community willing to attempt such a task (this very text testifies to this). In the context of agriculture, chromas have been considered objects for use with a clear purpose in mind – the analysis of the soil as living – but they could also be considered as this place where unconcealment or creation of a world takes place and thus worth preserving it. “The proper way to preserve the work,” says Heidegger (2008, 193), “is co-created and prescribed only and exclusively by the work.” Chromas need to co-dictate, as it were, their means of preservation. The preserver is given immediate access to this knowledge because he also plays the part of being a creator. As the reader might already imagine, the problem of interpretation here vanishes, as there is no longer a gap between the work/chroma and the preserver.

As preservers, we have arranged to make poems that accompany some samples of chromas. As semitexts – dependent on the existence of the chromas – the poems that follow attempt to insert a new mode of knowing the chromas. An intimate, aesthetic, intuitive mode that attempts to take chromas as works of art that might establish worldly relationships beyond those of the analysis of the soil. In expanding the scope of chromas and intimately working with the earth, we further intend to route the problem of the origin towards its closure. Could chromas be the origin of a world?

Completing the chromas [77]

a manera de carcasa	in the form of casing
despliegas ya la nube	you deploy the cloud already
te protege	it protects you
no solo del ambiente	not only from the environment
sino de tu contraparte	but from your counterpart
no te veo tierra	I do not see you earth

[77] Poems by Lucas Andino (www.primitivismos.com). We worked around this by having lengthy conversations about the theoretical and philosophical basis of the entirety of the text, and in particular about how we view chromas to be an application of the theoretical framework. Then we shared these particular chromas with the poet, Lucas, who, without having any knowledge on soil science, or on the practical interpretation of soil chromatography, or on the particular characteristics of the sampled soils, viewed the chromas and composed the poems (in Spanish but then translated them as well to English) based on their aesthetic quality.



sin analogía ni semblanza

tu granularidad se acerca

estamos dentro tuyo

quemas todo   arde

pero al hacerlo un espacio

se convierte en hospedaje

without analogy nor semblance

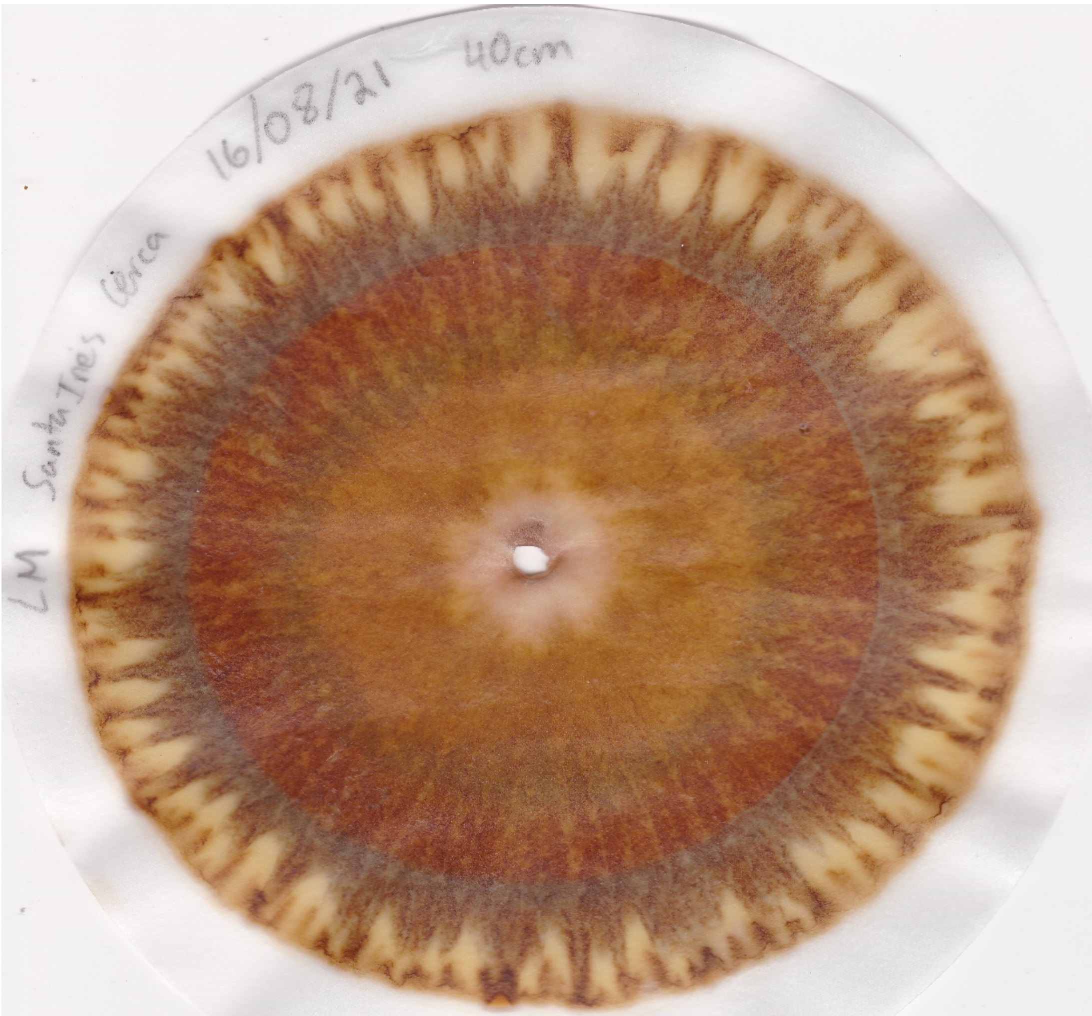
your granularity approaches

we are inside you

you ignite everything   burns

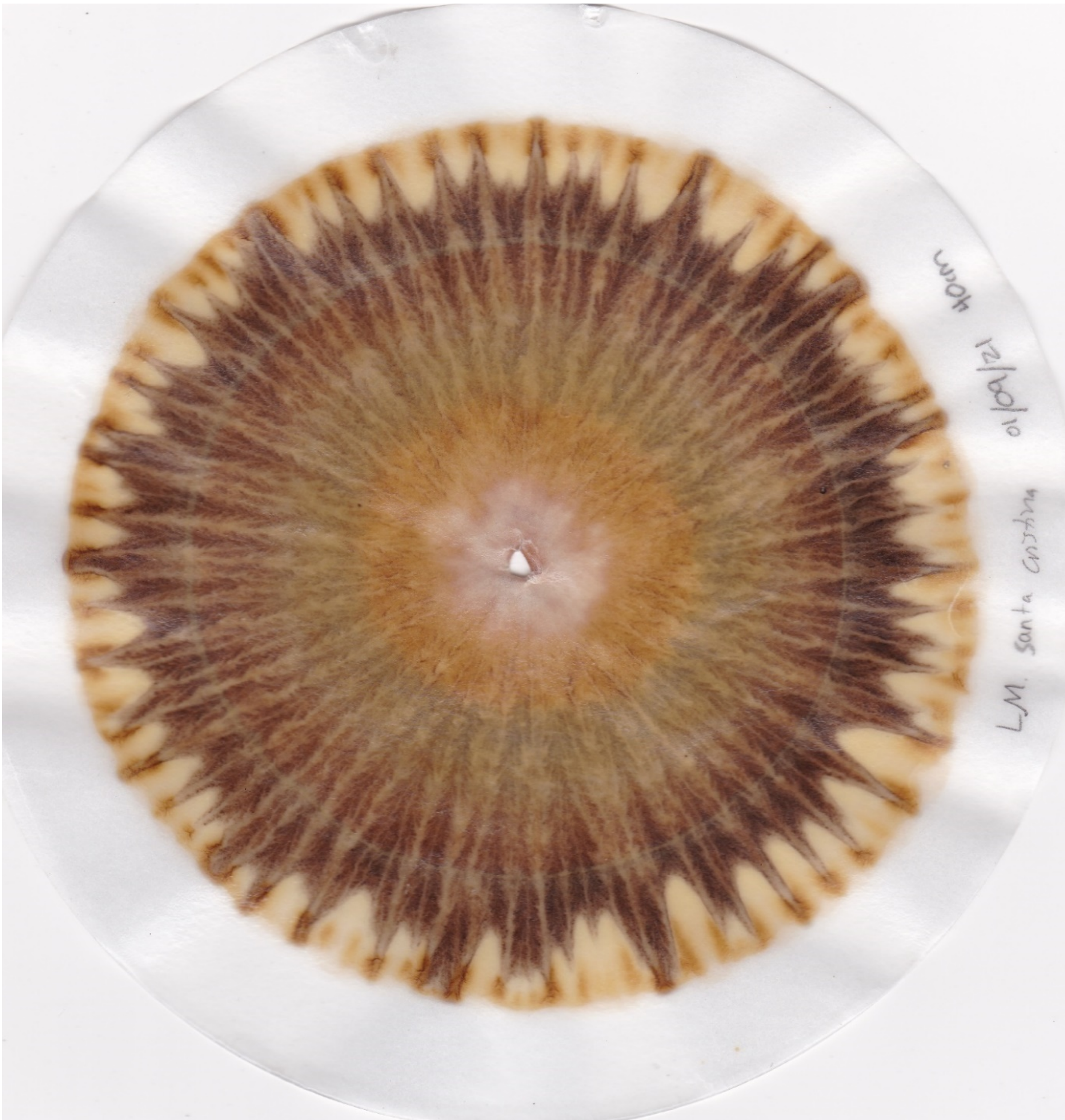
but in doing so a space

becomes a shelter



ya desbrozaremos de a poco
la riqueza de tus límites
algún día confiaremos
en la división de partes
por lo pronto no te alejes
déjame que me distraiga

we will gradually clear
the richness of your limits
someday we will trust
in the division of parts
for now don't move away
allow me to distract myself



he visto ya tu regla

tu necesidad que ahuyenta

no es de palo sino ácida

por eso cuando te recoges

dejas extendido el brazo

pedazo de regalo

I've seen your rule already

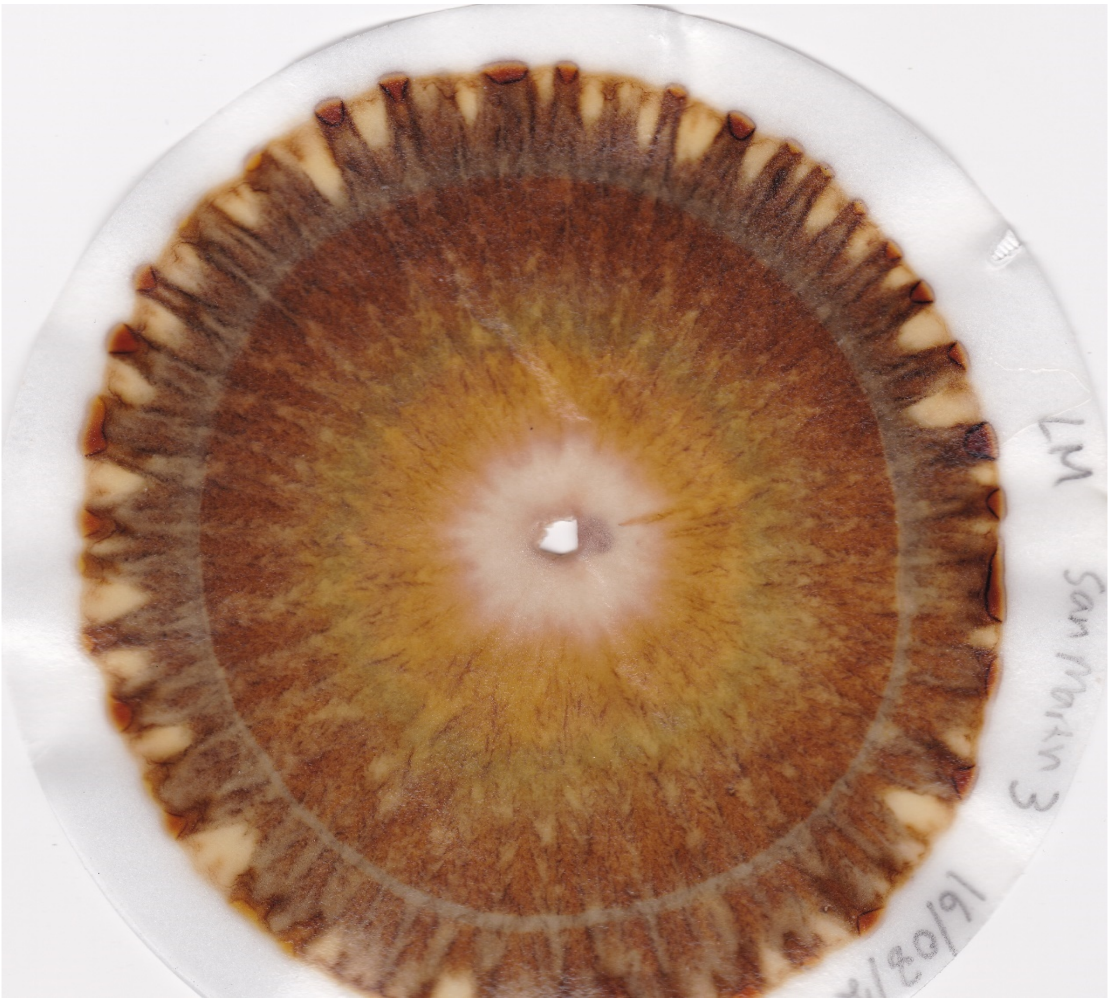
your need that drives away

it's not made out of wood but acid

that's why when you recoil

you leave your arm outstretched

a great present



hemos arribado finalmente

a un hábitat desconocido

sus bondades otras

lisas   parabólicas

con respecto al planeta

alguna vez llamado tierra

su valoración incierta

finally we have arrived

to an unknown habitat

its other provisions

smooth   parabolic

with respect to the planet

once called earth

its uncertain valuation

mantenimiento e indiferencia

a paso estable juegas

muy rara vez traicionas

yo solo aspiro a echarme

al solaz del grano

guías sin que me percate

maintenance and indifference

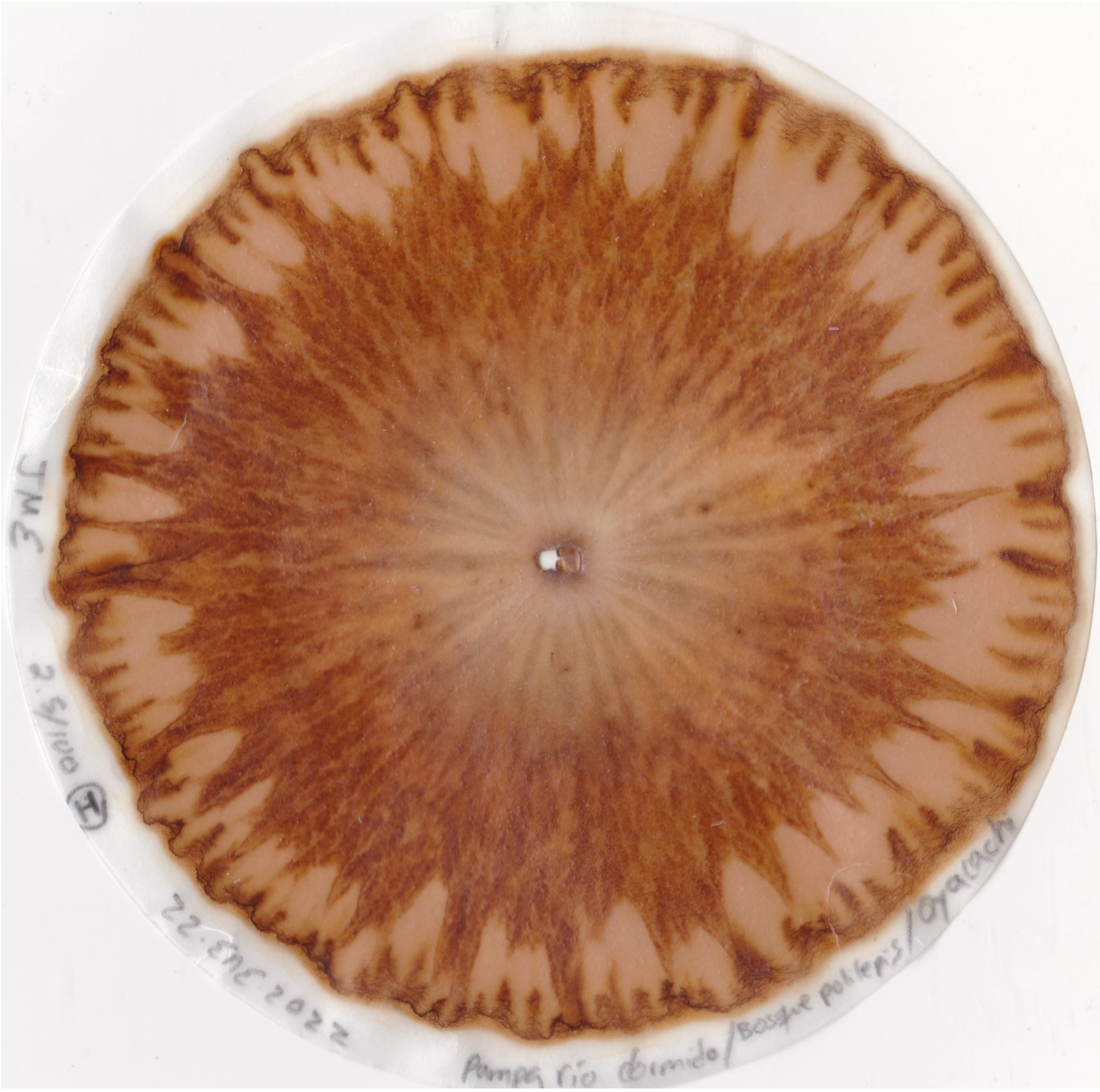
at a steady pace you play

very seldom do you betray

I only aspire to lie down

to the solace of the grain

you guide without me noticing



no estamos preparados

para amarte

hace falta que nos arrastremos

pero falta poco

basta que me topen

para regarme en escarpado

we are not prepared

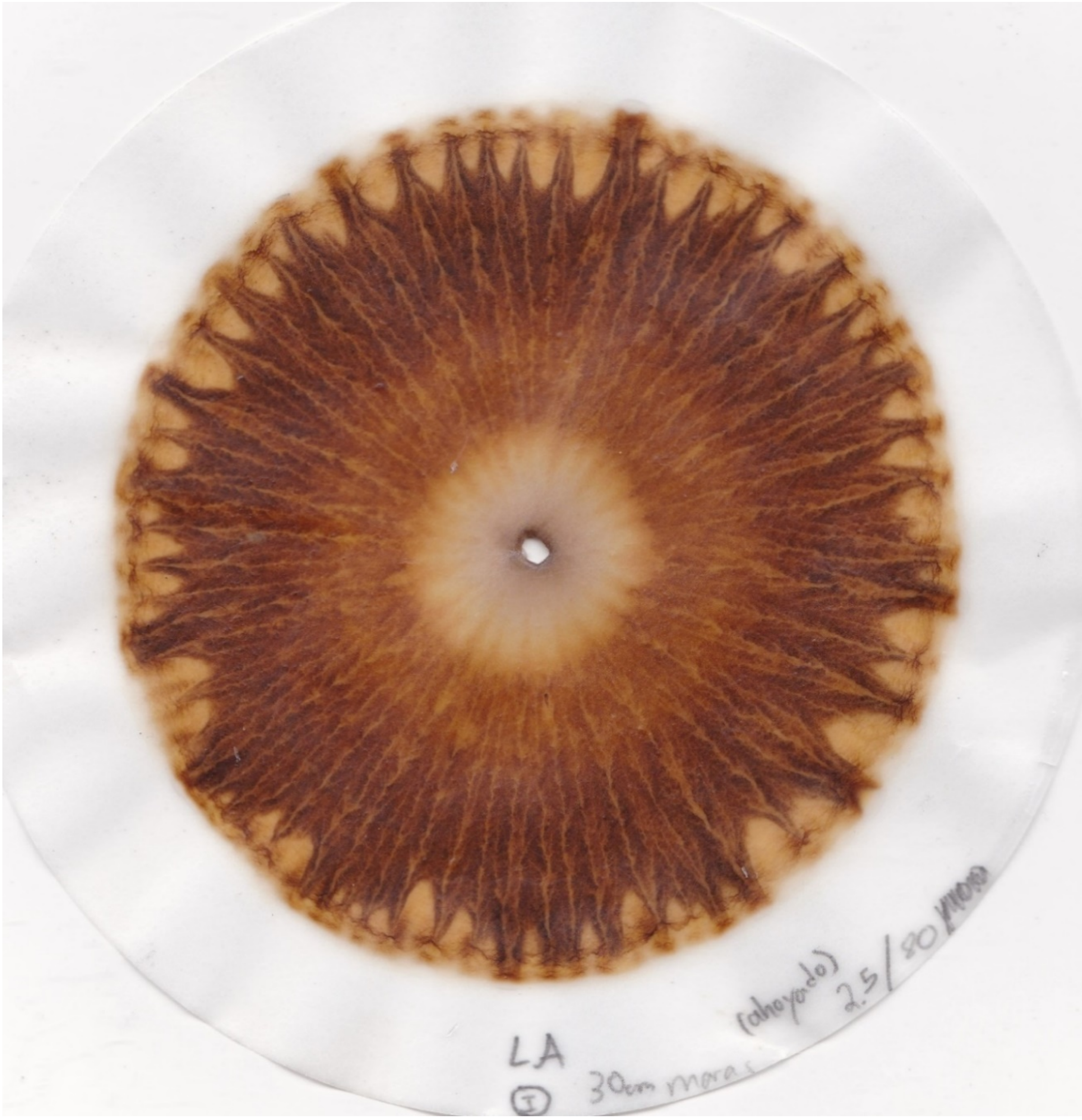
to love you

we have to drag ourselves along

but it won't take long

it is enough to touch me

for me to water steeply



cuando podía ver mis vísceras	when I could see my viscera
¿o era mi esfínter?	was it my sphincter?
tú cobrabas vida	you came to life
lucha entre comillas	a fight between quotation marks
para la cual doblegas	for which you bow
sin encontrar revuelta	without finding rebellion
tristemente mermas	sadly you diminish

piensas todo el día

aspiras a superponerte

y a pesar de ello niegas

la posibilidad del dualismo

la diferencia llama

pero contigo muto

all day long you think

you aspire to supersede yourself

and in spite of that you deny

the possibility of dualism

the flame difference

but with you I mutate

Chromatography worksheets [78]

Chromatography (the method, simplified)

Chromatography, the map of the soil. A map towards the health of a soil. A crosscut picture of the state of the soil at that time. It is a qualitative analysis that requires an interpretation that connects the image revealed in the colors, shapes, and patterns with the context and history of the soil and the sampler.

1. Sample the soil, dry them, ground them to powder, and sift them before storing in airtight plastic bags.
2. Prepare a 1% solution of NaOH, so to prepare 1 liter of solution dissolve 10g of NaOH in 1000ml of distilled water.
3. Then prepare a dilution of 0.5% $AgNO_3$ by mixing 0.5g of $AgNO_3$ with 100ml of distilled water. This is the photo sensitive solution to impregnate the filter papers and reveal the chromatographic image of the soil. Therefore, this needs to be stored in a dark container and/or wrapped in aluminum foil.
4. To prepare the filter paper, use the Whatman filter paper grade N˚4 15mm diameter. Find the center and punch a 2mm hole.
5. Prepare a wick from another filter paper cutting $2cm^2$ squares and roll into the hole in the middle of the punched filter paper. Mark spots at 4cm and 6cm from the center, as this will mark the limits of the impregnation of the sample.
6. Using a small petri dish inside a larger petri dish, fill the small petri with the solution of 0.5% $AgNO_3$ and place the filter paper on top, with the wick submerged in the solution. Then let it run all the way to the first mark at 4cm. This needs to be done in a dark room with as little light as possible or using red light. Once the solution reaches the 4cm mark remove them and leave the papers between two absorbing towels to dry in a dark box.

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[78] This section, including the following two sections in Spanish have been drafted for various workshops we have offered about chromas to farmers, artists, and academics.

7. While the impregnated papers are drying, dilute the soil sample with the 1% NaOH solution. Mix 5g of the prepared sample with 50ml of the 1% NaOH solution in an Erlenmeyer flask, or baby formula jars.
8. Now begins the process of mixing the sample and adding the dynamization process as this method has been developed and described. Moving in circular motions begin clockwise 6 to 7 turns, then counterclockwise 6 to 7 turns, and repeat this process 7 times. Let the solution sit for 15 minutes and repeat the process, letting it sit for 60 minutes. After 60 minutes repeat this one last time and let it sit for 6 hours. 3 dynamizations of 7 turns to each side 7 times.
9. Now with the dry and prepared filter papers (in a dark box) and soil solutions (dynamized 3 times and are now sitting for 6 hours), prepare the same arrangement of petri dishes and fill the small petri dish with the supernatant extracted with a syringe or a pipette taken without disturbing the solution. Place another wick and let the soil sample run all the way to the 6cm mark on the filter paper. Then the chromas are ready and need to dry and revealed by progressively exposing them to indirect light. It can take a full day to dry and at least 3 days to fully reveal all the patterns and colors. For storing them it is useful to submerge them in liquid paraffin wax and scan them, saving them in a folder protected from light.

Cromatografía de suelos – EL MÉTODO (RESUMIDO)

Se presenta un resumen de cómo realizar un cromatograma de suelos, de fertilizantes, sustratos, alimentos, o cualquier sustancia que quien decida hacerlo pueda experimentar. Se presentan los materiales, insumos, además del equipamiento básico y opcional.

La lectura de la cromatografía y su aplicación en el trabajo de regeneración de suelos, construcción de conocimientos, y producción de alimentos y medicinas es una tarea colectiva entre quienes quieran dedicarse a hacerlo.

1. Recolección de la muestra
    a. Recolección de mínimo 3 submuestras (es decir mínimo 3 huecos) a la profundidad deseada. Aleatorio o en Z
    b. Muestra compuesta molida, cernida, y puesta a secar
    c. Preparación de las diluciones ($AgNO_3$ 0.5% y NaOH 1%)

2. Impregnación papeles, dilución de muestras y dinamización
    a. Preparación de papeles filtro, hacer agujeros y marcas de corrido de sustancias y preparación de mechas
        i. Papeles de 15cm – marcas a 4cm y 6cm usar lápiz 2HB
    b. Dilución de las muestras. Diluir muestras en NaOH 1% en Erlenmeyer de 100ml
        i. Suelos "normales" – 5g muestra en 50ml de NaOH 1%. Suelos ricos en materia orgánica (andosoles o tierra negra) puede hacerse 5g de muestra en 100ml, 150ml, o hasta en 200ml.
    c. Impregnación de papeles con $AgNO_3$ y colocar a secarse en una caja obscura
    d. Dinamización: 7 vueltas a cada lado por 7 veces
        i. Primera – reposo 15 minutos
        ii. Segunda – reposo 60 minutos
        iii. Tercera – reposo 6 horas

3. Corrida y secado de las muestras

a. Extraer sobrenadante de solución de suelo y preparar en cajas Petri
b. Correr solución de muestras en papeles impregnados
c. Etiquetar y poner a secar cromas para revelado
d. Preservación de cromas en parafina

Análisis e interpretación de los cromas

Zonas

1. Central: componente físico del suelo, estructura, aireación, capacidad de almacenamiento de agua.
2. Zona interna: mineral. Moléculas más pesadas y componentes inorgánicos.
3. Zona intermedia: materia orgánica. Moléculas orgánicas, componentes y diversidad de microrganismos.
4. Zona externa: metabólica. Moléculas más pequeñas, principalmente enzimas y componentes proteicos de la metabolización de los minerales, transformación de sustancias minerales.
5. Zona periférica: Zona de manipulación del croma y de etiquetado.

Análisis de cada una de las zonas

a) Tamaño o proporciones de las zonas con relación a todo el croma y al tamaño de las otras zonas.
b) Colores. Deseables – ocres, amarillos, marrones, dorados, rojizos. Indeseables – negro, gris, púrpura, azul, verdes obscuros.
c) Patrones. Los patrones más deseables que se buscan son irradiaciones desde el centro, en forma de malla, plumas o túneles hacia el exterior. Plumas son clave, atención en cómo se irradian, qué tan visibles o sutiles son, y qué zonas abarcan. Es importante ver las terminaciones de las plumas en las zonas 3 y 4. Terminaciones deseables incluyen dientes angostos sin punta, llegando casi hasta el final de la zona 4. En las puntas de las plumas, un patrón muy deseable es una terminación como nube. Triángulo del final de la pluma con un triángulo invertido difuminado sobre este. Como el perfil de un volcán y su nube de erupción.

d) Transiciones entre zonas. Mejor mientras más sutiles y graduales sean las transiciones entre las zonas. Cambios drásticos o fronteras muy bien definidas, sean cambios radicales de los patrones o de los colores entre zonas no son deseables. Por eso la importancia de las plumas, mientras más visibles, más permiten una transición gradual entre las zonas.

Análisis estético integral del sobresuelo, de la muestra de suelo, de la muestra diluida, y del croma.

- La persona más indicada para analizar un croma es la persona que conoce lo que está creciendo en ese suelo, que ha visto el cambio temporal y estacional, que ha realizado intervenciones sobre aquel suelo, que obtuvo la muestra y realizó la dilución, lo dinamizó y pudo ver la muestra diluida, y que corrió la muestra diluida sobre el papel impregnado.
- La forma en la que uno se plantea un problema contiene implícita la forma en la que se buscará una solución al problema.
- La estructura del suelo no inicia de un análisis del tamaño de sus partículas (arena, arcilla, humus…)
- El suelo no es una sumatoria de elementos individuales en sus formas químicamente detectables.
- No se está analizando sustancias individuales (NPK, S Ca Mg B Zn Fe Mn), se analiza la diversidad mineral en su conjunto.
- Los elementos minerales no actúan solos o en aislamiento. Tampoco los microrganismos ni las plantas.
- El croma es una representación de las relaciones entre los componentes del suelo al momento de la recolección. Cada croma es único.
- Para un análisis completo de un suelo, se requiere una serie temporal, siempre en contexto con lo que ocurre arriba.
- La cromatografía de suelos provee un conocimiento localizado o contextualizado, a través de una representación visual incompleta, que no intenta retratar una realidad o una verdad total de un sistema abierto donde hay más aspectos desconocidos que conocidos.
- Por eso, además del análisis estructurado, está un análisis poético o estético del croma.

Protocolo de toma y preparación de muestras de suelo para cromatografía

Determinación de la zona de muestreo

Se debe tomar la muestra de una zona geográficamente homogénea correspondiente al mismo cultivo. Se puede dividir los lotes según sectores de observación o según las intenciones y planes para intervención. Adicionalmente, para mantener una homogeneidad y mayor precisión en el análisis, **es conveniente que los lotes de muestreo no sean mayores a 1 hectárea**. Es decir, si el cultivo es mayor a 1 hectárea, lo conveniente es dividir la zona de cultivo en lotes de máximo 1 hectárea en base a zonas que puedan ser representativas o que se quieran aplicar alguna intervención puntual.

Cantidad de submuestras

Nunca tomar una muestra única, siempre hacer una muestra compuesta de submuestras dentro de la zona de muestreo. Si escogemos un lote de 1 hectárea, se deben tomar entre 7 – 15 muestras dependiendo del tipo de cultivo. Mientras más submuestras se tomen de un área de cultivo, más específico será el análisis y los resultados. Se mezclan todas estas submuestras en un solo recipiente limpio (funda plástica o balde limpio). Por ejemplo, si se obtienen 15 submuestras de 200g se tendrá una muestra compuesta de 3 kilos.

Toma de submuestras

Hay muchas formas de hacer esto, lo que hemos practicado es iniciar en una esquina del lote de muestreo y lanzar un objeto aleatoriamente y tomar una muestra donde este caiga. Se va avanzando en un patrón en Z a lo largo del lote obteniendo muestras donde el objeto lanzado caiga. De esta manera **se evita "escoger" lugares puntuales** dentro del lote o zona que puedan confundir o sesgar nuestros resultados.

Cómo tomar las submuestras

Se puede tomar muestras con un barreno, y en caso de no tener esta herramienta se puede muestrear con un azadón o con una pala. En el caso de usar pala y/o azadón, se hace un corte en V al terreno de por lo menos 20cm más profundo de la profundidad a la que se quiere muestrear. Es decir, si se quiere una muestra de 30cm de profundidad, se debe hacer un agujero en V de por lo menos 50cm. Se saca toda la tierra y material vegetal del agujero y se limpian las paredes de la V para asegurar que no haya tierra de otras profundidades a la vista. Se selecciona la profundidad que se desea y **se obtienen 100 o 200g mínimo en cada submuestra** con una herramienta limpia.

Profundidad de las submuestras

Lo ideal es que todas las submuestras que obtenemos de un mismo lote sean de la misma profundidad. Si se quiere obtener muestras de diferentes profundidades en un mismo lote se las puede obtener del mismo agujero, pero se las debe ir colectando por separado. **La profundidad de las muestras depende del cultivo y lo que se tenga planificado para el terreno**.

Preparación y secado de la muestra

La muestra compuesta que se obtiene se la mezcla y se la limpia de piedras o de material vegetal que pueda haberse mezclado. Una vez bien mezclado, se extrae aproximadamente 500g o hasta 1kg y se lo extiende sobre un papel limpio. La muestra completa puede ser de hasta más de 5 kilos, pero **para el análisis de cromatografía se necesita alrededor de 200g.** Se puede usar el resto de la submuestra para otros tipos de análisis como precipitación, calcinamiento, o para enviar a laboratorios que hagan análisis cuantitativos.

Una vez que la muestra esté bien seca se guarda la muestra final, mínimo 100g y máximo 300g. Para transportación se debe enviar en fundas plásticas con cierre hermético y etiquetadas.

Información de la etiqueta

La información de cada muestra debe incluir como **mínimo** los siguientes componentes:

- Lugar de origen de la muestra (finca, hacienda, terreno…)
- Identificación del lote de la muestra (lote 1, potrero X…)
- Fecha de toma de la muestra (día, mes, año)
- Profundidad de toma de la muestra (30cm, 60cm, 120cm…)
- Cultivo

Adicionalmente se puede poner más información opcional. Tomar en cuenta que **mientras más información se tenga de la muestra, más detalle se podrá proveer** al momento de un análisis o interpretación de los resultados

- Condiciones climáticas al momento de recolección
- Hora del día a la recolección
- Contexto relevante (aplicación de insumos, riego, estadio del cultivo, etc.)
- Persona que tomó la muestra
- Propietario o trabajador del terreno o cultivo
- Historia relevante del terreno y de la zona

3.3 Working with soils: trees, pastures, and animals

The following are a series of narrations, recipes, instructions, and memories drawn from our autoethnographic journal. This section (as well as the chromatography section) is, in our opinion, the marrow of the entire project, as it hopes to live up to the theoretical, epistemological, and ontological framework that concerns us, exposed in Parts 1 and 2. It will necessarily be incomplete and limited within the aim of trying to explain soil, or trees, or anything concrete. Let us repeat what we mentioned above when attempting a practical explanation, and knowledge generation, from the chromas. It is an unending task due to the paradoxes of working within the dimension of life and the living, the limitations of our situation and our use of language. These practical or autoethnographic fragments (together with some encounters presented through the text) are the territories where unconcealment or creation of a world takes place. We aspire to immediate access to this knowledge because we have lived through it. There is no representation beyond the necessities of language, there is no interpretation as we narrate the work from within our body, and there is no truth-telling as what we attempt is a story that writes on soil, trees, and substances from their own perspectives.

The mountains, the valleys, the waterways

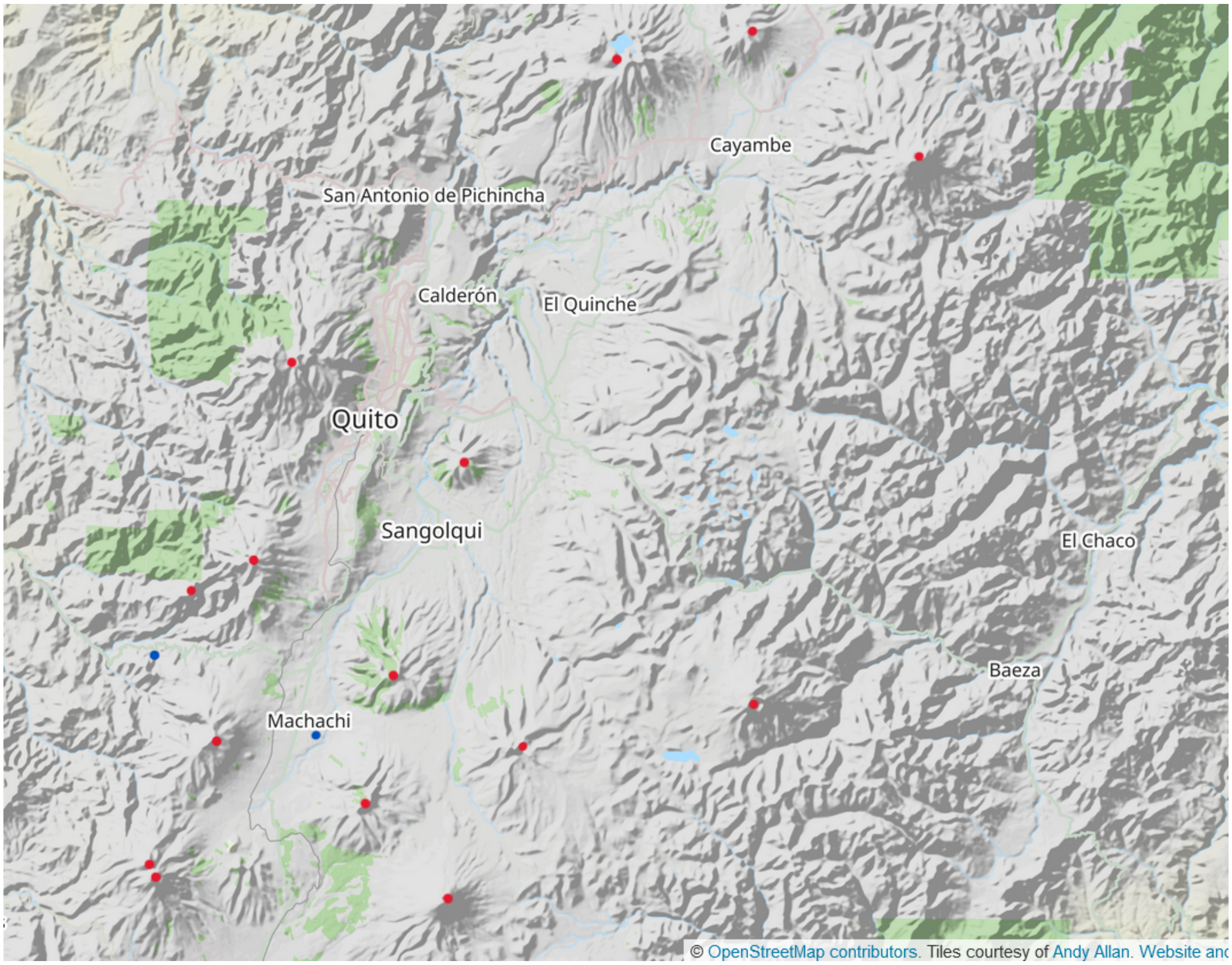

Figure 6. An open-street map capture of the Guayllabamba and San Pedro River basin. Red dots mark volcanoes narrated in the text, blue dots mark the two sites: La Maria and Los Alpes. "OpenStreetMap contributors. (2023). Retrieved from https://openstreetmap.org."

The Andean range runs through South America in a South-North direction. We could describe the Ecuadorean range as it opens to three mountain ranges on the south of Venezuela into Colombia, or from the high peaks of Tierra del Fuego as they expand north along Chile-Argentina, through the Bolivian Altiplano, and into the several ranges across the Peruvian Andes that end up in the rugged province of Loja in southern Ecuador.

It makes more sense, to us anyway, to describe the Ecuadorian Andes in a more limited way. Our main focus is on the northern portion of the Ecuadorean Range. We describe this “northern range” arbitrarily from the Chimborazo massif marking the southernmost limit to the knot or junction of The Pastos (nudo de los Pastos) in the north. This portion of the range, roughly 200km in longitude, is marked by a particular geography that we learned in elementary school that was divided in "pots" and "knots", to use the literal translations of how we learned them in Spanish, ollas y nudos.

The pots are the valleys within the two main mountain ranges: the eastern range that slopes into the Amazon basin, and western range into the Pacific coast. These pots would be a continual alley within the two ranges if it weren't for the knots, elevated regions that connect both ranges and therefore divide the different pots along the way. Another way to describe this "pots" would be watersheds, since the pots carry the names of the main rivers that drain them. The knots carry diverse names; sometimes the name of the main volcanoes or mountains that they connect, others of the peoples that inhabit their locations.

We were taught repeatedly and probably memorized the names of the "nudos y ollas" but we never really understood them until we began to pay attention and explore the mountains. We will go into more detail in the region we have lived most of our life and that we have explored to more detail, but of course, the more we wander around the more we realize we haven't even come close to realizing the vastness and diversity that this geography creates.

The city of Quito shares the same olla with the cities of Cayambe, Tabacundo, and Machachi, and many other towns and villages. Three "cantones" and over three million people in a territory of about 90km long for maybe 40 at its widest. This olla is known for its main river; it is the Guayllabamba basin, whose river cuts through the western range a few kilometers north of the equator and rushes westward through the Chocó, merges with other massive rivers that stream downward from the forests and mountains and forms the Esmeraldas river that, around 150km later after cruising (what used to be) lush rainforests opens up into the mangroves of the coast of Esmeraldas on the Pacific coast.

North of the river, the beautiful and still-glacier-covered Cayambe volcano has its skirts connecting with the Mojanda massif, that together with the Cubillin mount and the Imbabura volcano a few kilometers northbound cut through both ranges and split the waters of the Guayllabamba to the south and the Chota river to the north.

From this knot, called nudo de Mojanda, as we head south the Guayllabamba basin is flanked by high, some glacier covered, active volcanoes on the east: Cayambe, Saraurco, Sumaco and Reventador (these two a bit eastward into the Amazon but very active), Puntas, Antisana, Secas, Sincholagua, Pasochoa, Rumiñahui, and Cotopaxi. On the western flank, we can see the Guayllabamba watershed expands a bit further north that on the east on the side of the Cotacachi volcano, and then south with volcanoes that have a lower elevation on average than the eastern range, and no glaciers except for small remnants of the Iliniza Sur, they all had glaciers well into the 20th century. The western range main summits from north to south: Cotacachi, Pululahua, the Pichincha massif with its three summits (Ruku, "padre encantado," Guagua), Atacazo and Ninahuilca, Corazón, Iliniza Norte, and Iliniza Sur. At the southern tip of the watershed, the base of the vertical Iliniza Sur touches hands with the base of the Rumiñahui volcano; that can also be considered the western slopes of the great Cotopaxi. Here they form the knot of Tiopullo "nudo de Tiopullo" that splits the waters of the Guayllabamba basin and the valley of El Chaupi and Machachi to the north and the valley of Lasso and Latacunga to the south. The Guayllabamba basin is more complex than just a "pot" with a single river running through. Roughly speaking, we can say that it contains at least 8 valleys, depending how you count them (or name them), but here is our take on them from north to south: Atahualpa, Cayambe, Guayllabamba, Tumbaco, Quito North, Quito South, Los Chillos, Machachi.

The usual trajectory from our home (at the time of writing this) towards the place where we work begins in the northern Quito valley, which is a higher valley of 40km long and less than 5 km wide, flanked by the Pichincha on the west, Pululahua and Casitagua on the north, the hills and cliffs of the deep rivers on the northeast, Guanguiltahua, Itchimbía, and Monjas to the west that divide it to the lower and warmer valleys of Guayllabamba and Tumbaco, and the Panecillo that sits in the middle of the oldtown Quito and splits the northern and southern Quito plateau, or valley depending on perspective. We usually travel across the oldtown, through the Machángara river that begins on the Pichincha slopes and runs east on the northern side of the Panecillo, joining up there with the rivers that drain the Southern Quito valley, and up into the Monjas hill, following the old Capacñán[79] route.

As we climb into the Monjas hill, about 3000m, we lie in a junction of four valleys within the Guayllabamba basin. To the northwest the northern Quito valley; to the southwest the vast southern Quito valley, with the Atacazo volcano on its west until it rises into Cutuglahua and Santa Rosa hills, before opening again into the Machachi valley further south; to the northeast we have the Tumbaco valley, flat, and low on its more terminal end of the watershed, crossed by deep canyons of the merging rivers that come down from the Quito Plateau (Machángara), the rivers that flow down the eastern range (Pita, Chiche, Guambi), and the beautiful San Pedro that comes from the Tiopullo knot 40km south on the slopes of the Ilinizas. This Tumbaco valley, called in past times the valley of the Yaruquíes, is flanked on the south by the mysterious Ilaló. A very old dormant volcano that passes for a hill with its 3000m summit, sitting in the middle of this interandean Valley and opens up the valley known as Los Chillos to the southeast of the junction at the Monjas hill.

As we travel through the ridge of this hill, we can see the vast urban sprawl of Quito to the southwest, lying up high at 2800m before it rises into the Pichincha and Atacazo slopes. If you pass through there early enough in the morning, or late in the evening, you can see the clouds rushing in from the coast pass between these two volcanoes and filling the Southern Quito valley with lush and sometimes violent rainfall. To the east we can see the previously green valley of Los Chillos, famed also by its rain and thunderstorms that are popularly attributed to the Ilaló, and famed by the quality of the corn and beans it used to produce in massive quantities. Chillos is an old name for diverse colored beans. Across this valley, with a fast-growing urban stain, we see the high eastern range with the massive white canopy of the Antisana glaciers, sometimes visible if not covered in clouds. If you follow the Antisana south across the range, it is the Sincholagua volcano that you run into, but westward between these two lies the gorgeous

[79] Capak Ñan, translated as the great road, is the ancient Inca, and pre-Inca road that connected Quito to Cusco. After Spanish colonization, this transformed into the Royal Road, and now much of the Panamerican road follows the same track.

Pasochoa. This dormant volcano has its eastern slopes high and connects to the Sincholagua, and the southeastern to the Cotopaxi highlands. To the west of Pasochoa, the beautiful caldera covered in what might be the last remnants of lush interandean native forests, it protects a narrow passage that divides it from the Quito plateau and opens into the Machachi valley to its south. This passage is cleared by the San Pedro river, that comes flowing from Machachi, into the Chillos valley, flanks the Ilaló on the west and then continues through the Tumbaco valley before connecting to the Chiche and Machángara rivers forming the headwaters of the Guayllabamba river that will rush down to the coast cleaning up the mess of over 3 million people. As the ridge we travel south ends near Uyumbicho, right across the Pasochoa, we can now see its green caldera to the east of where we stand, and the Cotopaxi cone right behind it, but tall enough that it can't hide unless it shrouds itself with clouds. A bit further to the southeast, but still western to the Cotopaxi, we see the jagged cliffs of the Rumiñahui (stone face), as it marks the east border of the wide and green Machachi valley. The valley sits up higher than the Quito Plateau, and on the western side we see the Atacazo southern widow, a vertical cone of about 3800m called La Viudita (the little widow), and a flat smooth connection to the gentle but lengthy slopes of the Corazón volcano. Further south of the large and gentle slopes of the eastern slopes of the Corazón, if it's a clear day we can see the impressive peaks of the Ilinizas, Iliniza sur still covered with some permanent snow and portions of glaciers. On summer dawns, at this point, you can see the crown of the Chimborazo beyond the Tiopullo knot between the Rumiñahui and the Ilinizas, lying 150km to the south but being 6800m high it shows its massiveness only when you get there early enough to beat the clouds.

As we head down from the ridge into the Machachi valley, we are usually impressed with the perfection of this geography, it is a gift beyond comprehension. To have a valley like this, completely closed on the east by the high massifs of the Pasochoa, Rumiñahui, Sincholagua and Cotopaxi, and straight across to the west the Corazon and the Atacazo open between them a gap that allows for the moist air from the coast to come in twice a day and slip into the valley, run across it and when it reaches the eastern walls it charges up and showers the Machachi and the Chillos Valley, and the Southern Quito, with lush rainfall that most of the year can be counted on to come at the afternoon like it was scheduled for. Following the San Pedro River through the valleys, the higher portions El Chaupi approximately 3200m, Machachi 2900m, Tambillo 2800m, Uyumbicho and Amaguaña 2700m, Los Chillos and Sangolquí 2500m, Cumbayá and Tumbaco 2200m. Each of these valleys and regions share similarities but hide subtle differences, marked by the elevation and their humidity, also reflected in their soils. The soil of the Machachi valley is miraculous, and this is not a euphemism or a metaphor. The mineral richness from its volcanic origin combines with the gentle but continuous moisture it receives, and with a multispecies alliance that has been present since the timeless past, the depth of the dark soil is deeper than in any other places of the Guayllabamba basin, as far as we have been able to attest. Probably like the Chillos and Southern Quito soils, but they are now mostly covered by urban landscapes. The depth and blackness of its organic matter layer shows that this land is not neutral or inert. It shows that it has been “grown” by deeply covered forests, edible landscapes and more recently patched with fertile pastures.

This is what Humboldt coined as the “Avenue of Volcanoes.” A name that stuck and continues to be used, since the metaphor is noticeably clear when you can sit high up and see the valleys flanked by massive volcanoes on both sides, and the smooth rolling narrow valleys between them. The Machachi Valley, for instance, is flanked by 9 volcanoes in an area of less than 800km2. When reading about Humboldt (Rúales and Guevara 2010), he made an observation that we previously thought was our own. It is known by people that walk the mountains that it is common to have the (perhaps sometimes correct) feeling that your feet are the first to ever walk those lands, that it’s impossible to see others before you venture into so seemingly untouched places. Something you see in journals of European explorers and geographers presented as a fact, to be the first ever to be there, hence, to claim it. It is of course, most commonly a deceitful feeling, as it was regarding our observation that Humboldt and probably others have made. On this region and most of the northern Ecuadorian Andes, when volcanoes reach a certain time in their histories, they break their cones into open calderas, and they always open towards the west. Let us review all the broken volcanoes coming from the North on the western range. Cotacachi, Pichincha, Atacazo and Corazon, all open up their calderas to the west, even the inhabited Pululahua crater opens up to the west. The Ninahuilca, a separate volcano hidden on the southwest of the Atacazo, active and smoking, lies on the west of the Atacazo summit and also opens westward. The Guagua Pichincha, with its history of spectacular eruptions, has never directly threatened Quito sitting on its eastern lap, which lies so close to it, because of its westward opened caldera. The Corazón volcano, just as the Atacazo, seems from the interandean valleys to be a smooth rolling hill all the way up to the jagged rocks, but this view hides the fact that on their western sides they open up to vertical cliffs that receive lush clouds and rainfall protecting virtually impenetrable and dense forests. These patches of forests within the calderas of the Atacazo and Corazón, as the Pichincha and the northern Cotacachi, have managed to maintain remnants of inaccessible cloud forests that hold as reservoirs of the biodiversity of both high interandean ecosystems as well as the lower tropical Chocó forests. Likewise, when we sit in the valley and look to the east, we see the wide mouths of the Rumiñahui and Pasochoa opening up towards the valley, westward, creating sheltered cul-de-sacs that form headwaters and the last remaining patches of interandean forests. Even the old and mystical Ilaló has its caldera opening up to the west, creating the valley guarded by the community of La Toglla. If we can gear up our imagination, we can see the Nazca plate heading east and diving below the continental plate from west to east. As the earth rotates eastward, the volcanoes rise with this force coming from below and from the west, and the combination of these forces eventually force the volcanic cones to break in the same direction.

The Andes are walking to the east, into the Amazon. Every day, when we see the open crater of the Pasochoa and the smooth hill of the Corazón we wonder and amaze at these invisible and timeless forces. Once we reach the Machachi valley, if we head towards the eastern side of the valley, between the Pasochoa and the Rumiñahui volcanoes, we reach the San Pedro River. This river has its headwaters a few kilometers south from springs on the Ilinizas and Rumiñahui and drains all the valley on the eastern side as it travels north into the other valleys until it reaches the Guayllabamba river close to Tumbaco on its march towards the Pacific Ocean. Right before we cross the San Pedro River, at the feet of the Pasochoa and Rumiñahui volcanoes, we find a farm of 30 hectares (74 acres) already surrounded by urbanism, called La Maria.

La Maria is one of the sites we have worked with, a farm dedicated mostly to dairy cattle production, where we produce the various kinds of biofertilizers, and a 200m^2 garden that feeds

10 families. The other site, called Los Alpes, is another farm, larger in extension (100 hectares) but in a different region, and mostly worked for agroforestry, reforestation, and conservation, as well as the place where young cattle grow before heading to La Maria when they reach a milk-production age. To reach the Los Alpes, we need to cross the western range and leave the interandean valley towards the coast. We head west right between the Corazón and the Atacazo volcano, passing next to la Viudita, following a lower pass of the range where the waters break and we begin the steep slope towards the Pacific Chocó, following the main road that connects the mountain valleys to the coast. As soon as we begin to head west from the pass, about 3300m, we have reached a different climate, a cloud forest that receives a continuous daily dose of clouds from the coast. Approximately 15 km to the west form the highest point of the range we reach a hill, which lies on the northwestern tip of the ridge of the Corazón Volcano, Cerro Bombolí [80], with a summit of 3200m, at its base we reach the place known as Los Alpes.

[80] Bombolí is not really a hill, a butte is a better translation. Some claim that it is a dormant volcano on its own, or perhaps an older offshoot of the larger volcanoes in the neighborhood. Regardless, it has a caldera-looking-formation that opens to the west and countless water springs in its base.

Image 33. Facing south, we see at the back the Illiniza couple, in front of them the old Corazón. The photo must be early morning as the sun shines from the east (left) and we can see the clouds coming up from the coast in the west (right) and on the lower right corner, a hill with a crater abover called Bombolí. Los Alpes lays at its base. Photo by Jorge Anhalzer. Used with permission.

Tree-hugger-with-a-chainsaw -The Pines of Bombolí

We will begin narrating our work with the planted pine trees in Los Alpes. A work that resulted from the intentions of improving the health of the soils where we raise animals and grow food, and the lessons this work has provided us have been invaluable in situating ourselves as agents of change in a multispecies alliance that works towards abundance.

We are definitely what could be called a tree hugger; it is our love of trees that sparks the irony in the pleasures with using the chainsaw, and what we have learned is that chainsaws can actually be the machines with larger potential allyship for trees and forests. Through our farm work of producing food, we are also reforesting and conserving approximately 100 hectares of high cloud forest; in the past decade we have planted over 20,000 trees. We are also collecting soil samples and identifying all the native trees and shrubs as possible from these cloud forest remnants—some of them have been posted on iNaturalist[81]—and slowly building up an id guide of native trees and local mushrooms. A particular part of the farm work that is fantastic, also curious considering our intentions, is cutting down trees.


Image 34. Los Alpes at sunrise. Photo by author.

Before we share some of the chainsaw work, it may be useful to describe the history of Los Alpes in some more detail. The photo above pictures Los Alpes at sunrise, facing east. Located on the western slope of the western Andean Range, on the highest portion of the bioregion known as the Chocó, and 2800 meters or 9200 feet high. The same altitude that Quito lies across the range within the interandean valley. It is a cloud forest with continuous moisture coming in from the pacific coast twice a day. In the 1960's, the region was a part of the development plans by the

[81] https://www.inaturalist.org/people/mateoec

state to expand into unused “wasted” land and turn the forests into “usable” farmland. These slopes have been longtime inhabited, but perhaps mostly as connection point, by both the people of the Machachi valley and by the Yumbos, an ethnic group described during colonial times, a people with relations of present day T’sachilas, a nation that lives down the slopes, to the west, in the humid rainforests of the Chocó. The government in the 1960’s would give property titles to those who go into these deep forests on the slopes of the Andes and clear cut them for grasslands or agriculture. The opening of the main road from Alóag to the coast really changed the scenery of these high cloud forests of the Chocó. Our grandmother participated with a peasant community that claimed this place called *Sociedad Campesina Los Alpes*, with people coming mainly from the Cotopaxi and Tungurahua provinces. The high humidity for most of the year and the scorching summer with no forests anymore to maintain humidity during summer times made life difficult for agriculture, pastures, and cattle. Within 20 years the Sociedad Campesina was dissolved, and most people sold the land and left. Our grandmother bought more plots from the people that left and unified into what is now approximately 100 hectares, of these close to 45% of the total area is devoted to reforestation and conservation.

Over 40 years ago, a wood cabin was built in Los Alpes. Around that time, our father also began planting several pine tree patches on hilltops and hillsides of the farm. By this point (late 1970’s – early 1980’s), the farm and the region had followed the path of deforestation as development. Along the years, the pine trees grew alongside potato fields and pastures for cattle, horses, and sheep.

Image 35. The wood cabin with the pine forest patch behind. Photo by author.

The last pine trees were planted around 15 years old, the time when we started reforesting only with native species, mainly alder. These pine tree patches are now dense tree forests with old trees about 2 or 3 meters wide and 20 or 30 meters high. They have really been the landscape of the central area of the farm, and we have learned to feast and enjoy the fungal abundance they shelter, mainly Suillus Luteus, that flushes every year in greater quantities.

Image 36. Hongo con su velo. Suillus luteus, slippery jack. Photo by author

Image 37. Suillus luteus bounty. Photo by author.

These pine trees are now also a key resource for the farm, as they are now the main providers of wood, as we only harvest them instead of touching any of the native trees. They grow considerably faster, bigger, taller, wider, than any native tree. Alders are probably comparable in speed and size, but the older ones are about 20 years younger than these mighty old pines.

Encounter 9 – Early Mornings, Trail To La Playa

When awake at the cabin in the middle of the night we find it hard to stay in bed. Perhaps due to the lack of digital overstimulation –bedtime is rarely past 9pm–, or perhaps due to its remoteness from large urban centers, and the shade from city lights that the mountain range provides, the nights are usually very clear, even when there is no moon. Provided that there is no rain, of course. Catching a glance of the silhouette of the Bombolí against the starry sky is an invitation to go out.

At 3.30am the herd is brought from the pastures into the stables for the morning milking, lasting about one hour plus another 30 minutes of washing and giving milk to the calves. The process is done around 6am at most, just before sunrise. At this time everyone involved goes back to bed or to have a warm and abundant breakfast to come back out at 7.30 where other daily chores begin. Milking the cows is not our favorite task for a variety of reasons, so we take the early shift and bring the herd in and then head up for a walk to catch the sunrise.

Harnessing the willpower to get out of the warm bed and venture out to the cold to walk through the grasslands or forests right before sunrise is a very rewarding experience. It reminds us how special is the routine of this work that provides a daily dose of meditative hours.
Silence is deep before sunrise. It is also the coldest time of the night. The silence and cold are probably enhanced by the contrast with the noise –by birds mostly– and the warmth that comes with dawn and the first rays of the twilight. After leaving the herd at the stables for the milking, we frequently take the train down to La Playa. A stretch of plain pastures, the largest flatland of Los Alpes, that lie beyond a short climb and a steep descent through an old beaten road. The Playa is like a bowl hidden by hills on one side and bordered by a stream that runs next to a rising cliff where Los Alpes ends. If we leave the stables around 4.30, usually sunrise will catch up to us halfway down to the road that comes down to the valley by the west, so we can face east with the plain below us and the cliffs and the rest of the range climbing into the clearing sun.

This trail is special to us, it is a reminder of the power of the forest to reclaim what human hand and machine had done. When we were in our teen years, this road was wide enough for a small truck to go in, my father's old Nissan and go down into a disappeared corral at the farthest edge of the plain by the stream. My father had opened this road and cleared the plain for pastures for "finishing" the bulls. He raised herds of bullfighting cattle, and taking advantage of the natural isolation of this valley he could send the mature adult bulls here to finish their weight gain without seeing any humans, besides Mariano, who would check up on them bringing salt and water to them. He was the only one that could go into the pastures without fear of being chased away by these wild animals. The truck needed to go into the corral so we could load these beautiful and furious beasts into heavy wood and metal crates that would carry them to the arenas and popular festivities around the towns of the Andes, that usually include bullfighting games. Visiting these bulls was intense experience due in part of the amazement of dealing with such wild and dangerous animals, and in part due to the knowledge that most of them were headed to a bitter end to serve a strange cultural and folkloric tradition.

These bulls are long gone and there is no need to bring down there any vehicles anymore. Over 15 years have passed, the road is now a narrow trail that is only relatively widened when the heifers go to the pastures, approximately every 90 days. We have begun to identify the main trees and vegetation along this trail that have grown into the path over the years. Slowly it is turning into a botanical scenic trail.

One of these pine patches of about 40 trees was planted right next to the cabin, which now hid under the shade of huge trees all around it, lying in a hole of dark and humid forest spot. Summer winds had already done some damage with falling branches, but if an entire tree happened to crash down it would be the end of the cabin, the nearby power lines, and anything else in a 20m radius of the patch of trees. We decided it was time to change the landscape for the cabin and began to chop down the patch and make the most out of the wood.

Knocking down the trees was quite a challenge, but it was only the first of many more chainsaw jobs to come. Most of the patch was growing on a slope, but trees had to fall sideways or up the slope, since the main access road and power lines passed right under the patch. The work involved climbing up the 50m giants using ropes and harnesses, climbing spurs, and the will to go all the way up to feel the tree alive and rocking you with the wind in the canopy. Secure a chain as high in the tree as possible and connect it to a cable pulled by a hoist anchored to the ground several meters away to pull the falling tree towards that direction. The first couple climbs we would come down and shake for several minutes, both from physical exhaustion and adrenaline.

Image 38. Lino milling trees freehand with a chainsaw. Photo by author.

We got better with time, but most of the work was done by Lino, a hired arborist that lives nearby. We assisted in felling the trees, so for that we had to call in a cousin, Tomás, a professional tree climber and arborist that actually knew what he was doing. We decided to call him for falling the most dangerous trees around the cabin, after one went the wrong way and wrecked the power lines.

Lino taught us quite a bit of the actual chainsaw work of milling the trees into boards, planks, posts, and firewood. His skill to do straight 2cm wide boards and posts of any size with the chainsaw is admirable. He also showed us his skills producing benches, chairs, stools, and other kinds of chainsaw furniture. In addition, he has been a source for identifying native trees with common names. A logger knows the trees. With all the wood we built two more stalls for calves, changed all the corral and stable, built a new three-bedroom house with an office and storage by the stables, and changed all the old power line posts throughout the farm. We also racked for drying lumber hundreds of boards and beams. Besides all the choice wood such as these, the process generated so much of other uses. The "jampas," the wane splits from the sides of trees, were used to build a second corral and chute for the farm, barriers to prevent slides into the access road (some neighbors carried a few to build pig and poultry pens), and we have now more firewood that we have been able to collect. This work inspired us to find out how

Image 39. The pine patch being worked, mountains of firewood, planning the new native forest patch, and a few babies going in the ground. Photos by author

to produce substantial amounts of biochar[82], as most of the "wood waste" is left unused. Added to the other pine patches and pruning we have intensified, and the enormous volumes of woodchips, branches, leaves, and firewood in general sparked our interest in biochar, but a lot of it is also left on site to add organic matter to the thinned forests.

These introduced species of the pine tree, which came in to replace grasslands that replaced cloud forests, are now so generous for everyone around, including being part of the work to invite the cloud forest to grow back. Sun now shines on the cabin and there is now space for the small grove of Arrayán, Pusupato, Yalomán, Chihualcán, and many others. We have fenced the area from cattle and planted a patch of slow growing native trees, with planting of shrubs and other species to speed up the recovery. To invite the chaparro to move alongside the cabin and turn it into another forest patch, not a tree patch.

ENCOUNTER 10 – EL CHAPARRO

El chaparro es ese lugar al que no entras a menos que estés comprometido a hacerlo. Espeso y bajo, como dice su nombre, con abundante vegetación pequeña y arbustos, algunos espinosos y otros ponzoñosos como la mora o las varias especies de ortiga. Chaparro es aparentemente un bosque terciario, un remanente de la intervención humana. Un espacio que está a la espera, tanto de ser convertida en pastizal, invernadero, urbanización, como de ser olvidada, o protegida, hasta que vuelva el bosque.

After this hectic work, we now periodically visit fallen trees with the chainsaw, and have a sense of urgency to dive more into the forests with the chainsaw. It's not only about chopping

Image 40. The thrill of falling a large cypress threating to destroy a neighbor's house. Learning to do some freehand chainsaw milling. Photo by author.

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[82] See section on biochar below.

down pine trees but pruning forests as they grow can really have an influence on the outcome or change the time scale for some of the species. Applying spatial justice, in the words of Luke Bergmann.

A multiple alliance of the aliso tree; the pastures that benefit from the alder's nitrogen fixing and moisture capture capacity; the cows that can graze in the shade and provide its beautiful shit; the soil with all its life that continues the transformation of cow shit and the growing rhizosphere of grasses, bushes, and trees; and the humans that are using their brain, their observation, and their chainsaws to imitate forest dynamics to transform a place into a healthy food producing space.

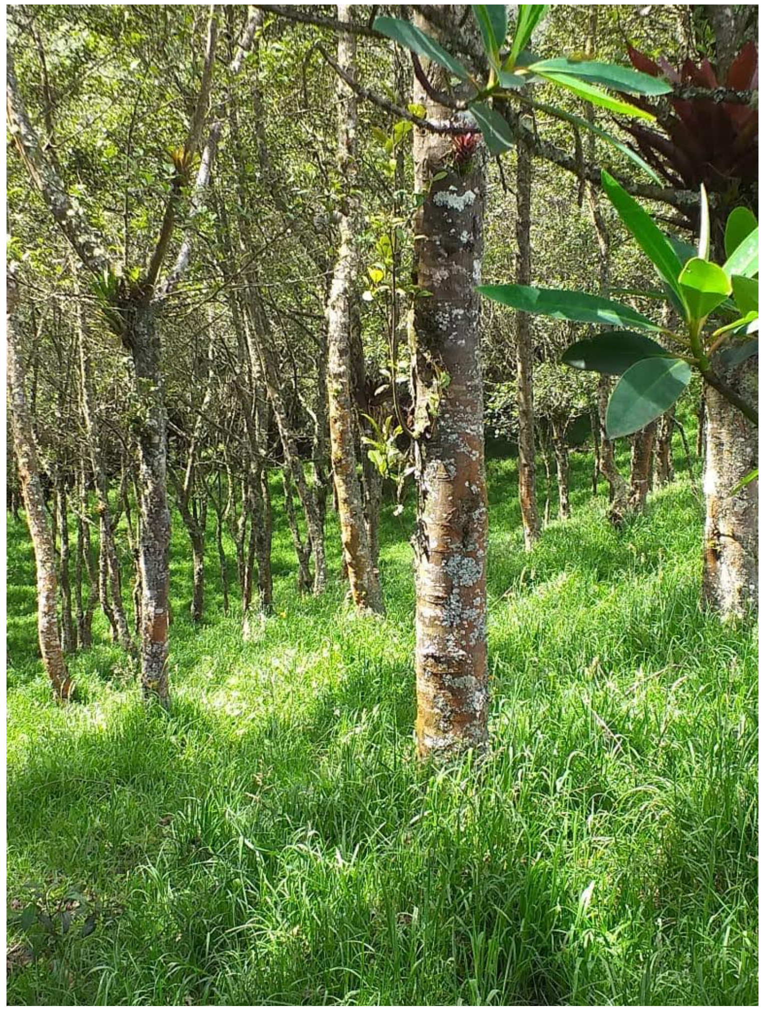

Image 41. Alder forest patch with lush pasture. Photo by author.

We visited a patch of forest that we planted approximately 15 years ago that needed our chainsaw. On one side, it is all alder that have now grown at least 40-50cm wide and several meters high, they form a canopy that has a slight shade on the pasture below it that thrives and receives the cattle with fresh green grass even in summer times when grass growth is noticeably slower throughout the region.

Image 42. Pine patch with no pasture, but with fungi. Photo by author.

The other side has some pines, alternating with cypress. The contrast is stark. If under the alisos the grass is lush and green, under the cypress and the pines it is dark soil with little or no grass. You can only see pine needles and rotting wood, even some eroded exposed land in areas that the cattle wonders through. This is, however, a place for fungi that doesn't grow on grassland or the aliso forest. So far we have observed at least 10 different species but have only identified the genus of a few Suillus, Gymnopus, mycena, trametes, macrolepiota. Generally speaking, the abundance of macrofungi in temperate regions -where pine trees come from, bringing in their fungal allies- is contrasted with an abundance of microfungi within the herbal diversity of tropical rain forests like the Chocó.

Life finds a way and even though the pine trees won't bring in the chaparro or the cloud forest to grow as easily, findings such as this abundance of macrofungi really checks the inner fascist that commands us to eradicate all introduced species such as the pine trees and allow only the native trees we decide to grow. There are still plenty of pine trees that need to go to help the forest come back, but it's not our intention to eradicate them all.

Image 43. Heifers grazing among planted alders and naturally sprouting native vegetation. Photo by author.

The pine and cypress patch had never been pruned or thinned, unlike the alisos, where once cattle come in, they perfectly prune the lower reaches of the trees marking their growth upwards, also killing a few of the smaller trees widening the distancing of the forest. Some cypress trees are small, many have dried, like the grass below, after being covered by a thick canopy above. We have thinned this patch several times now, but we still have work to do, bringing in the multiple alliance with things that grow, always with soil recovery at its main goal. The key member of this alliance, the one that can jumpstart the process of regeneration, is our chainsaw. The healthiness of a place and its inhabitants is measurable by the abundance of life it sustains, and as a healthy forest is an abundant soil, an abundant soil is a healthy planet, humans included. We find it interesting that in this attempt to work for a healthy soil, a chainsaw has become a favorite tool.

Burning pyres for the earth – making biochar

Making biochar, or charcoal, was supposed to be easy. After all, humans have been doing it for a very long time. The process is to combust vegetable matter at high temperature but with low oxygen, this is called pyrolysis (breaking down with heat). This process burns away much of the chemical elements but rearranges the main building block of organic matter, Carbon, into its porous and stable structure known as charcoal. If the vegetable matter pyrolyzed is fresh and thick, like recently cut wood in large chunks, the result are thick briquettes of charcoal highly desired for smokeless burning, such as preparing food or warming human homes for centuries, powering machinery since the 18th century, and to produce electricity in much of the world during the 21st century. If during the process of pyrolyzing, air comes in, the plant material will turn into ashes, not charcoal.

Image 44. Building a buried charcoal furnace, second attempt. Photo by author.

After our work with chainsaw, we had mountains of brush, branches, firewood, and sawdust. Our only option was to turn it into ash by open burning. We still used the ash for bokashi, for supermagro (see subsections below for this products), compost piles, or just to spread on the thinned forest as in situ potash fertilization. Even after shifting to use steel drum calcinators that would burn large amounts of brushwood into ashes quickly, we realized that we were missing an opportunity to produce a valuable soil resource and a prime material for supplementing and improving the quality of many of the biofertilizers we were working with. We made a few efforts of making charcoal "the old way," which all our instincts comforted us that would be the easier way. We were wrong.


Image 45. Building a buried charcoal furnace, fifth attempt. Photo by author.

The old way involves careful arrangement of equally sized logs into a mound, covering it with soil, grass, and sawdust, and then lighting it up without letting air get into it. Also praying to the old gods to give us a few days of no rain in the cloud forests of the equatorial Andes. Depending on the size of the mound, it can take up to a week of continuous burning, checking day and night that no vents are opening, or the mound is collapsing. We will not share much more detail on the exact process that is required to be a success, because we failed several times. We were having fun failing anyway, because we had so much "wood waste" that these failed charcoal mounds were just wood buried with incredibly vigorous grass growing on them. When the fourth or fifth mound of wood would turn off on day two, crushing our expectations, we decided to look for alternatives. The first alternative was to plant trees on these mounds, creating giant hügelkultur[83] where we planted several nogal trees, as a hallmark to remind us that beautiful tree patches can grow from your failed plans.

We had been thinking about this for a while, and then we found Mark Shipperlee, the founder of Green Man Enterprises, who gave a talk at an online workshop titled "Introduction to Biochar: A soil improver & soil lockdown"[84]. The premise of his presentation was the following, "one of the challenges in woodland management is what to do with waste from harvesting. Making biochar on a small scale allows carbon to locked into the soils for thousands of years." We agree that

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[83] In hügelkultur, large masses of woody material are buried beneath cultivated soil to serve as a long-term water and nutrient pool. This wood is, of course, primarily degrade by fungi and, as such, can be experimentally inoculated with species that can tolerate soil contact, such as Reishi (*Ganoderma lucidum*), Nameko (*Pholiota nameko*), and the Brick Cap (*Hypholoma sublateritium*), among others. We are still waiting for the opportunity to do a "planned" hügelkultur, but so far, we have two failed charcoal furnaces turned into planted tree patches.
[84] See full conference at https://www.srs2021.com/events/introduction-to-biochar-a-soil-improver-and-soil-lockdown/ .

carbon is some-thing some-people want to "lock into" outside the atmosphere, but our intention is not to keep carbon away, but to help microbiology use this carbon to transform it and other minerals into rich life-giving-humus. Anyway, Mark Shipperlee pointed us in the right direction, and that was the Kon Tiki Kiln.

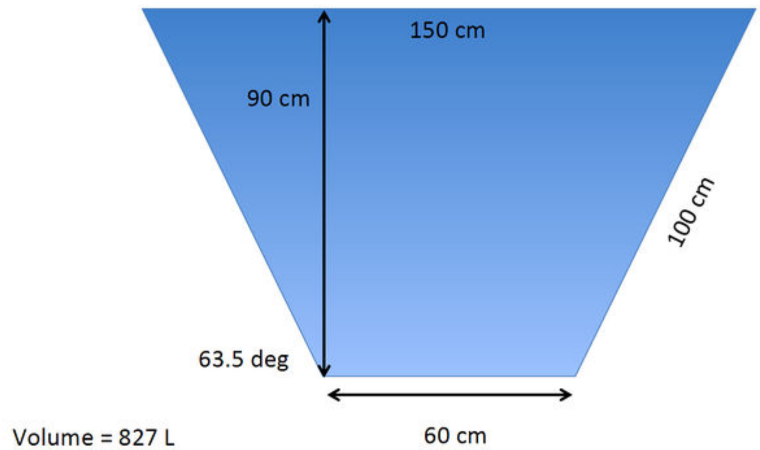

Figure 7. Kon tiki kiln design, based on Ithaka Institut instructions.


Image 46. Ecuadorian version of kon tiki kiln. Photo by author.

We used the open-sourced designs of the Ithaka Institut[85], designed to pyrolyze any kind of organic matter, from brushwood to sawdust, corn husks or tree leaves. We have documented that with the dimensions we show on image X, we can produce 700L of biochar in 5 hours. With this sketch we visited a trustworthy and adventurous metal worker, and we came out with a kon tiki designed to fit on the back of a pick-up truck and hauled into any forest being thinned.

The method for the kon tiki kiln to produce biochar is as follows. We start a fire at the base of the cone and keep piling up homogeneously sized material over it. Once the fire is working, an air current is created to drag air inside the cone in the middle while pushing air from the sides. May be hard to explain this but the end result is that air exchange only happens

[85] See the entire documentation and work about the development of the kon tiki kiln here: https://www.ithaka-institut.org/en/kon-tiki

Image 47. Kon tiki beginning, ready for a new layer of material, close to finished, and finished product ready. Photos by author.

at the surface of the burning material. Once we begin to see ash form on top of the burning area, we add new material to be burned, and continue this way until the cone is close to being filled with burning material that is red hot on top. If we would leave this burning, ash would begin to form from the top to the bottom as organic matter is in contact with air, so we need to stop the burning process immediately by flooding the cone.

After it cools down, we drain the water, which is now very alkaline, also known as lye. We save some of this water and use it to clean stable floors with satisfactory results. Perhaps someday we can also produce soap and detergents with this byproduct. What comes out of our furnace is charcoal. If our vegetable material was small enough brushwood, less than a thumb's thickness, the result is almost powdered charcoal, just as we wanted it. Spread it out to dry, or not, grind it further depending on the use intended, and bag it in 30kg sacs ready to go to the bokashi or compost piles. If we place this charcoal in a 200L plastic container, and flood it with supermagro, or with liquid Native Forest Microorganisms (or worm tea, or raw manure water, or any other source of microorganisms) we have what is commonly called "activated biochar", probably the best mulch in planet earth, the best addition to a seed germination substrate, and unnamable other uses and benefits for healthy and abundant life on our planet. Eventually we realized making biochar is quite easy and it is about so much more than sequestering carbon away from the atmosphere.

The Eucalyptus Tree – A tenacious and controversial ally

Anyone that has seen the Andes may be familiar with the predominant tree in the region, the eucalyptus. It is not a native tree, but an introduced species that has gained undeniable hegemony over the landscape. In what follows we will provide a limited review of the tree's ecology and history in the region, continued by a narration of our relationship with the tree. From loving it, to hating it, to accepting it. Understanding our relations with this tree has been a crucial aspect in our path to learn how the construction of a healthy milieu requires us to see things from different perspectives, a path that has managed to shift our perspective on this tree through time.

Eucalyptus (Eucalyptus globulus), also known as Tasmanian blue gum or Southern blue gum, is a tall evergreen tree that is native to Australia and Tasmania. The species has been widely introduced in other parts of the world; it is widespread in the Andes throughout South America. The eucalyptus tree is adapted to a wide variety of climates and thrives in regions with hot, dry summers and mild, wet winters. They prefer deep, well-drained soils and can tolerate occasional frost and fires. Eucalyptus trees can grow to a height of 60 to 75 meters, with a trunk diameter of up to two meters. The species is known for its rapid growth rate and ability to grow in degraded or nutrient-poor soils. Eucalyptus trees are also known for their ability to extract large amounts of water from the soil, which can be either beneficial or detrimental to surrounding vegetation, with documented effects of displacing other plant species (Bayle 2019).

Eucalyptus trees are members of the Myrtaceae family, and are characterized by their woody, oval-shaped fruits that contain numerous small seeds. Eucalyptus trees are also known for their distinctive leaves, which are long, narrow, and pointed. The leaves contain oil glands that produce a strong, aromatic scent. Eucalyptus trees are pollinated by insects such as bees, flies, and wasps. The seeds are dispersed by wind and can travel long distances, allowing the species to spread rapidly. The species is also able to regenerate quickly after wildfires, due to the presence of epicormic buds on the trunk and branches.

The species gained popularity as an ornamental plant in Europe and North America during the 19th century. Eucalyptus trees were also valued for their wood, which was used for building, furniture, and paper production. In the early 20th century, eucalyptus plantations were established in many parts of the world to meet growing demand for wood pulp. Today, eucalyptus trees are grown for a variety of purposes, including timber production, essential oil extraction, and reforestation. The species is also used in traditional medicine and has been shown to have antibacterial and antiviral properties. (Dhakad et al. 2018).

Eucalyptus trees were first introduced to South America in the late 19th century. The species was initially imported for ornamental purposes, but it was soon discovered that eucalyptus trees could be grown commercially for timber production. The tree shares a similar history throughout South America (Dickinson 1969). Today, eucalyptus trees are widely cultivated in South America (Farley 2007; Sarmiento 2002). Eucalyptus plantations in South America are typically established on degraded or abandoned land, as the species is able to grow in nutrient-poor soils. The trees are also able to extract substantial amounts of water from the soil, which can be beneficial in areas with low rainfall. Eucalyptus trees are typically harvested after 5 to 10 years of growth, depending on the intended use of the timber. Eucalyptus timber is used for a variety of purposes, including paper production, construction, and furniture making. The species is also valued for its essential oils, which are used in the cosmetics and pharmaceutical industries. Despite its economic benefits, eucalyptus cultivation in South America has been associated with some environmental concerns (K. White, J. Ball, and M. Kashio 1993). The species is known for its allelopathic properties, which can inhibit the growth of other plant species. Eucalyptus plantations may also lead to the displacement of native vegetation and wildlife (Sarmiento 2002). This argument is constantly revisited in the region by those with some ecological awareness, and although it is a valid statement, the issue is more nuanced. To gain a more complete picture of the impacts of the eucalyptus on the ecology of the Andes, the negative aspects of the introduction of this tree to the region need to be understood from the perspective of the tree as well. For that, we recur to our memory and trace our own path of our relations with eucalyptus.

Eucalyptus reverie

It’s morning, hard to tell what time exactly, it doesn’t matter. Engulfed something to eat from the kitchen table, put the rubber boots on and rush outside. Mom yells something from the door frame, and we instantly know what it is without understanding the words. Stop the sprint on the gravel road forcing a skid mark, run back to grab an oversized cap, and run even faster back to the stables. This morning we’re not interested in checking in on any animal, at this time of the day there's only calves in their stalls. But we bolt into the storage room where we know we will find a rope and a medium machete. It's a small machete so adults rarely use it, also it's easier for us to carry around and swing. Now we just walk while we catch our breath and finish swallowing what's in the mouth. We head slowly to the paddock next to the stables where the two horses spent the night. We like to ride the black one more, but he's younger and more spirited, we would need a saddle and reins for him, and we still can't lift the saddle. It scares us too much to ride him bareback. So, we go to the pinto. He's an older horse, slow but also more relaxed and docile, he lets us go anywhere alone. We are also strictly forbidden to take the black one alone to the forest where we are heading. Sink the machete on the doorpost while we open the fence, roll the rope, and hold it behind our back so we can hide it from the horses. They are surely not fooled by this, but we still do it. Then we begin to walk very slowly with our free arm extended with a relaxed fist in front of us, as if offering something to them, back slightly crunched, shoulders down, eyes looking down and walking very slowly. The horses see us and raise their heads. They suspect we might be bringing raspadura (also known as panela, a delicious solid form of sucrose derived from the boiling and evaporation of sugarcane juice), but the black one doesn't care, or is not fooled, and walks to the opposite end of the paddock. The pinto focuses his ears and nose to us to confirm his suspicions, but when he realizes the deceit, we already have the rope over his neck, and he knows out of habit not to move anymore. We tie the rope and make a loose muzzle so we can improvise reins with the rope. Give him lots of love with caresses and voice thanking him for being so nice and take him to the cobbled road outside the paddock. Close the fence, position the horse next to the fence, wrap his mane and rope with one hand and climb the fence until we can jump over his back. The pinto stays immobile as the friendly horse he is and lets us try it two times before we can struggle and climb on his back. The machete is now at reach so we can grab it from the post, and off we go after a few clicks of the tongue that signaled the pinto that we can go. We only take him at a trot since we are not too steady going bareback and we have to hold the rope and the machete. Being only 10 years old, we felt like a fully competent and capable adult going out for an adventure in the forest. When we went out to play into the forest, alone or with our cousins, we called it “playing Daniel Boone.” We don’t know how we came up with that.

The cobbled road travels from the stables for about three kilometers with pastures on both sides. It ends in a crossroad where the road turns into a dirt and grass path. Going straight goes through the last pasture and into the forest road. The path diverting at the crossroads heads down the slope through a couple more pastures before reaching the San Pedro River. The forest, as we call it, it's a strip of no more than 200 meters of slope from the edges of the flat-ish pastures above down to the edges of the quebrada that flows from the west range of the interandean valley and joins the larger San Pedro River that flows from the Iliniza knot to the southwest. The farm limits on the east by the San Pedro River that has the smoother slopes hence less forested and with the quebrada (ravine or stream) called ayaurko, that must translate to something like the devil's mountain, but not very sure about that. Ecologically speaking, a very intervened place that was surely deforested down to bare soil, and the vegetation now is composed of the remnants of what managed to resprout and what came with the water or the birds, and the overwhelmingly dominant species is undoubtedly the eucalyptus tree.

We have a lot of memories of this tree and the forests it has created on the slopes and ravines of the inter Andean valleys. The memory of this morning ride to the woods in our childhood days is an example of that. What motivated us to go there, this and many other days, was our relationship with that tree. It was the reason for us to head there, it was why the place was called “the forest.” We loved the tree before we were old enough to learn how to hate it. Later, we were taught that it was introduced, it was foreign, and that it destroys the soil and dries the land. Yearning for a forest made-up of other trees that we didn't know as well as that tree at the time, nostalgia for a landscape we hadn't known, that no one living today had ever seen. Writing these memories, we are also beyond hating the tree or aching for things we know little about, but what we can really see is that we still love that tree, and that it's here to stay. Whatever the reasons that brought him to these valleys it came to change history, or least the history of these lands.

Our visits to the forest through childhood were all about the trees, the eucalyptus trees. We would wander around long enough to find a tree that was straight and thick enough for us to chop with a small machete. Sometimes we would get ambitious and choose one with a base of approximately 30 centimeters thick, that was incredibly thick for a 10-year-old to chop with a small, often blunt, machete. In these cases, we would chop it the full day or at least what felt like the full day and come back the next day to finish it. The moment when it cracked and fell was probably the most exhilarating, but then came the task we loved the most. Peeling its bark. Eucalyptus bark peels off easily when fresh, especially young shoots like the ones we chose. The bark peels off in smooth strips leaving behind a moist and slippery round wood, light colored and with the smell coming from the aromatic oils within the tree. Young shoots also carry young leaves, different from the mature tree leaves that are thicker and more elongated. The young leaves are greenish blue, oval, soft, and with an extraordinarily strong scent. If you squash one under your nose or bite the tip of one, the scent and flavor would stay with you for hours. These leaves also have a waxy mantle, oily and sticky mantle that stays in your fingers when you touch them.

The capacity that the trees have for coppicing or resprouting after being chopped to their base, or burned, is incredible and borderline magical. These are what Anna Tsing calls peasant forests (Tsing 2015). Patches of forests where the trees are chopped down before they can get too big to manage with hand tools, useful for posts, construction scaffolding, and firewood. The result is a shrubby looking forest, with enough light for abundant grass for grazing animals, and woody shrubs easy to chop. This capacity is a remarkable resilience strategy by the eucalyptus, and it is perhaps the key ability that has allowed it to spread and stay in vast amounts of land everywhere around the world.

We recall a conversation with a group of women activists while doing work for a different project. We were organizing focus groups and interviews in the city and some surrounding rural areas


Image 48. Genus laetiporus (chicken of the woods), growing on a dead eucalyptus tree in the Machachi valley. Photo by author.

regarding their use of community gardening projects and selling their produce to organic markets. As usual, the most interesting information was shared when the cameras were off, and conversation happened spontaneously. We were in the car and one of our colleagues voiced a comment about how sad it is to see all the hills covered in eucalyptus trees. A common statement by ecologically aware people around here. There was an awkward silence for a moment, and one of the women asked very politely what we thought about the eucalyptus trees. We said that we made peace with the trees when we started keeping bees, since the trees flower massively and are a wonderful nourishment for bees. Their flowering is greatly expected and welcomed since it promises honey and a buzzing beehive, healthy and active. We also mentioned that we've found that there is a well-known edible fungus that can grow on dying eucalyptus trunks, known in northern latitudes as "chicken-of-the-woods," from the genus laetiporus. We have hunted this mushroom widely for several years and we keep a record of large trunks that fruit every year that we go back to. As with the pine trees and their pine mushrooms, this fungus surely came with the tree to these latitudes, and it is another gift it shares with us.

Besides, we added, if there were no eucalyptus trees, it's likely that the hills would be barren and actually sad looking. The women chuckled and our colleague continued saying that the tree is detrimental to soil quality, it dries the land and takes the space of native species. Of course, she is right in that, but that fact doesn't deny all the benefits we find from the tree. One of the women took up the conversation and said that to think negatively of the tree is characteristic of people that have never used it or benefited from it. She strongly agreed with our argument about bees and added that the tree is medicine for humans as well as bees. It is used for coughing and respiratory sickness, for colds, and usually when there is phlegm and nasal congestion, as infusions and mainly vaporization. But the main use is to cleanse spaces, as a bunch of fresh young leaves is used as a broom for doing “limpias.” This was February 2020 but talk about a virus spreading in China and Europe was already heard of, and the use of eucalyptus for protection from this was being discussed. Conversations then flowed to it, and we were left with even more conviction than this tree it is loved as it is hated for valid reasons on both sides.

Animals

Our work with soil is done mostly by and for the animals we raise. Cattle primarily, with the main emphasis being milk production. For some time now, we have seen the shortcomings of being economically dependent on a single product, since we sell the milk raw and in bulk to the dairy processing industries that process the milk into added value products such as pasteurized milk, yogurt, cheese, butter, and the whole production chain of dairy. But we have neglected that there is another layer of valuable resources associated with the raising and caring of cattle: meat.

Our purpose is that our task is the production of food, for us and as a commodity to give us the rent required for a decent quality of life and for being able to sustain the land, allowing us to continue caring for the land that our grandfathers have left us. With this in mind, we have begun to raise some of the male calves, a practice that requires sacrificing valuable space in our pastures reserved mainly for female animals, desired for milk production, as well as introducing genetics of different breeds more suitable for meat than dairy. This means that from a purely Holstein herd, the herd now has animals with genes of other breeds such as Montbeliarde, Normande, and Brown Swiss. We have also experimented with some purely meat-oriented breeds such as Angus and Brangus (Brahman and Angus hybrid) breeds. That is one side of the process of finding ways to produce meat as well as milk, but the other aspect is what we decide to do with the dairy cows when they have reached their daily production limit, by age or reproduction issues.

In a dairy farm, an animal that can no longer get pregnant, for whatever reason, is no longer productive as it will not produce milk. Cows are mammals and for them to produce milk they need to pass through the cycle of pregnancy, delivery, and the subsequent lactation. When a cow delivers, we wait for one cycle of ovulation and then immediately attempt another pregnancy, either by artificial insemination or by direct mount (a bull). Once the cow is pregnant, she continues to produce milk until three or four months before the next delivery. Gestation time is 9 months, so a normal lactation, from delivery to when the cow is “dried”, is approximately 7 to 8 months, considering the approximate 40 days after delivery when she is pregnant again.

Taking a step back, let's follow the animal from birth to its first delivery and beginning of milk production. After birth, the calf drinks her mother's colostrum for the first three days, after that they continue to drink milk twice a day, two or three liters at each take, and we offer some grain feed and fresh or dried grass for them to nibble. These are not for nutritional needs but mostly to encourage the development of their rumen, the grazers that they are. Once they reach three or four months, they are progressively weaned and their grass intake increases, for them it is a learning process, and they begin to eat more when they can. We will describe later how a cow develops in more natural settings such as in a wild herd or when raising beef animals, but now we are focusing on the conventional pasture-based approach to raising a dairy animal. After weaning, and once they are better at eating grass, they go to a pasture in small (6 to 12 animals maximum) of the same age where they continue to grow, depending on the pastures you offer them supplementing at the very least salt and mineral supplements. They continue their growth until they reach 300 to 330 kilograms of weight, usually about 13 months of age, when they are ready to get pregnant for the first time. After pregnancy is confirmed, and when they are three months from delivery, their diet and situation change once again and they are moved to mature pastures, higher in carbohydrates, and supplemented with extra dry hay, feed, and silage. This helps them reach delivery with a better body condition (fatter), and their rumen expands considerably thus increasing their capacity to graze and produce milk during the metabolically demanding period of lactation. This way, the herd continually adds new members to the lactating group, as new heifers reach their first delivery. Approximately 50% of these deliveries will be female, and the process continues. When dealing with a limited pasture space, this means that as heifers reach cow-hood, cows need to also leave the herd. Replacement is needed to keep the herd healthy and productive. There are cows that reach a certain age and will get sick or die of "natural" causes, for us the main ones are eye cancers due to high UV exposure—remember we are three kilometers above sea level at the equator—or a metabolic syndrome called "fiebre de leche," hypomagnesia or hypocalcemia after delivery, but that has been greatly reduced by mineral fertilization of soils with magnesium sulfates in the biofertilizers. There's also the occasional accident, lightning, a falling tree, a slip and fall into a ravine, but they are also very infrequent. With the controlled and highly efficient reproduction rates we have, even if we only keep the female calves, the herd population will continue to grow as these deaths are massively outnumbered by healthy births. So, there is a need to continually cull the herd. But how do we choose the cows that need to go? They all have individual names (not only numbers) and we all know their stories. Sometimes they are remarkable at birth, or we remember that this cow is the daughter of such other cow we loved or, is the mother of the beautiful heifer that was just confirmed pregnant, or we remember that one had a fall that recovered, or countless stories of life and health, inevitable when you deal with living creatures that have individual personalities, stories, and anecdotes. The decision, however, is an economical one. If a cow fails to get pregnant after two or three cycles (months), and her lactation ends, she is a candidate to leave the herd, or if there have been repeated abortions in the early stages of pregnancy. We never give up immediately, for instance if there is a heifer that has failed three artificial insemination attempts, we bring in a bull, they live together for a few months, and it usually does the trick. But if the bull fails to get her pregnant, and we know the bull is healthy and fertile, then she becomes a candidate to be culled. So, the main reasons to choose an animal to be culled, from an economic perspective of the dairy farm, are usually reproductive reasons. A quite different story happens in an industrial CAFO or grain-based dairy farm. Our animals can live long healthy lives, although the reproductive pressure is high on them.

Imagine the life of these animals. They wake up, and graze, and if during lactation go to the stables where they get milked while they nibble some salty minerals, eat broccoli[86], and go back to their pastures to find that the fence has been moved and there are fresh pastures for them. After getting filled, they sit down and ruminate for hours, occasionally walking a few steps to drink pure cold spring water. There are no natural predators for them, the humans that deal with them are always gentle and, with the exceptions of the occasional veterinary checkup, no one

[86] We receive a daily truckload of broccoli, which are the trunks, leaves, and bits produced from a broccoli exporting industry in the valley that chops, freezes, and exports broccoli to all around the world.

even touches them. We've had animals that reach 15 years of age while being productive (milking, pregnancies…), and a few exceptions of animals that have reached close to 20[87].

In a month, we have at least two or three animals that need to go to avoid overpopulation of the herd; these are called "discards." The approach has been to sell these animals to cattle dealers, which will either resell them or take them to slaughterhouses and sell their meat. They pay meager value based on the weight and condition, but they always make a decent profit by reselling the meat themselves. Observing this situation, we decided that, even out of respect to our animals, we need to change this practice, and if we need to continually cull the herd, we will process the meat ourselves.

We will avoid going into the details of the butchering and meat processing business but let us share another side of the story: a cattle raising farm that does not produce milk, but only cattle for beef. Our father managed herds this way when we were growing up, and we have very fond memories of this process. For starters, this requires a different breed of cattle, since breeds selected for dairy produce much more milk than what a calf can drink, so milking them is required, otherwise they will develop all sorts of problems that are incompatible with their life. Their udders will swell and develop mastitis, an infection of their udders that is life threatening. The process to raise cattle beef we will describe here is entirely pasture based, and of course there's plenty of nuances about it that we will omit, as with the dairy cattle, but present a general idea and mainly contrast the differences with raising cattle for dairy production.

In the beef cattle scenario, when a calf is born, they drink the colostrum and then they stay with the mother and the herd and drink milk directly from the mother. The cows, and their calves, graze together for at least six months when the calf is weaned and separated by taking them to another pasture with their cohort, leaving the mother to "dry" and rest for the lactation. Ideally,

[87] We vividly recall a cow called "Libertad," who lived when my grandfather was still around. Libertad never got pregnant, never produced any milk, and her body constitution was more bull-like. The term is *machorra*. However, she was the spoiled favorite of everyone, since she was the best "heat detector," and her bull-like attitude kept all the cows in the herd calm and relaxed, without the problems that an actual bull can bring. Bulls can be dangerous to humans, especially when they get older, and they can actually get cows pregnant when, for any reason, we want to avoid that. Libertad lived over 20 years.

the mother cow was pregnant again within 40 to 60 days after calving, and so when their calf is weaned, they are close to six or seven months pregnant, and then they can dry up and wait before the next calving. In pasture fed, pasture finished cattle, the animal reaches maturity at about 18 months, but the older they are the more their meat matures, gains intracellular fat, and the quality of the meat generally improves. In contrast, grain fed, or grain finished cattle (not necessarily in a CAFO) can be ready for processing at 12 to 13 months; this is because, due to their diet, they artificially gain weight and fat content much earlier. They become obese, we might say, and that is the standard in the beef industry.

There's always a third way, and in this case it's no exception. We are still developing this idea with help and support by well-known gourmet restaurants that look for quality and have a sense of ecological and planetary responsibility, while at the same time respecting that the farmer needs to achieve an economically sound production. The idea is to have milk cattle raised through the process we described, and once the animal is no longer economically viable for dairy, but still healthy in every other way, we dry them up and move them to mature pastures for several months/years with only supplementing minerals, so that they can gain good body condition, fatten up, before slaughter and processing. If this way works out, we will achieve the actual meaning of a double purpose cattle raising venture. Happy old animals, at least over five years of age, which have produced milk and eventually also offer a high quality, highly nutritious, healthy, food for humans.

Phosphites from bone

In his seminars and books Jairo Restrepo[88] (Restrepo and Agredo 2020; Jairo Restrepo and Sebastiao Pinheiro 2015) presents the need for P as part of this balancing and general nutrition of soils and plants, using easily available materials and techniques that any farmer, working at any scale, can use. As we stated previously (Chapter 3.1, subsection Phosphorous), P in bones is mainly in Pi form, sorbed by Calcium and unavailable for mobilization and absorption by plant roots. Traditionally, the method to separate Ca from Pi uses an acid that reacts with $Ca^3(PO^4)^2$ to change P into a phosphorous (or phosphonic) acid H^2PO^4. Jairo's strategy is much easier to work with, but the outcome is P in Phi form (phosphoric).

The first step involves calcinating bone, a process done at high heat to remove all carbon molecules from bone (fat, flesh, blood, etc.). This transforms bone to a clear white color that easily crumbles into dust when crushed. It took several steps and lots of high low-tech engineering to perfect bone calcinators from used steel barrels.

Image 49. Calcinating bone. Photo by author.

[88] We have attended two week-long seminars and have assisted and collaborated closely with people trained by him in soil health and chromatography workshops. Most of his work is available online @lamierdadevaca.

Around Machachi, and any countryside we would imagine, there is no shortage of bones. Many of the cattle dealers that we sell old or sick animals to are always very willing to bring truckloads of bones for free, we save them the trouble of disposing of them.

Image 50. Calcinated bone grinded and sifted into bone meal. Photo by author.

After calcination we grind the white bones to dust, or flour. Bone flour or bone meal. We tried stomping on them, driving over them, crushing them with rocks or bare hands, and it all worked when we were doing less than 10kg of bone flour. Now every batch is at least 100kg of bone, so we found an old chain mill (molino de golpe) that was refurbished perfectly with an electric motor, and now grinding bone is a pleasurable task that only requires a shower afterwards. Once we have the bone flour, the process is to pyrolyze it (high temperature without flames and low oxygen) in combination with a source of an element that may be able to react with the Ca and free the P from its strong bonds. The element we use is silicon Si. Si is present in many forms in plants, but especially high in grasses. You have probably felt the rough glass-like cutting edges of a blade of grass, that is silicon [89].

Image 51. A load of rice husk, cascarilla. Photo by author.

Our next raw material is another cheap and highly abundant product called cascarilla de arroz, the shell of the rice grain. Remarkably high in silicates and many other rich elements, mainly

[89] See section 3.1 Minerals.

Image 52. Lighting up the phosphite bazooka. Photo by author.

potassium. Some people use the ash of the cascarilla on its own as a silicon and potassium rich fertilizer. We get a truckload from the rice processing plants on the coast approximately twice a year for less than a $1 a sack. To pyrolyze the bone ash with the cascarilla we needed to build a bazooka. That is Jairo's term, because he claims that this “weapon” is deadly for green revolutionists when we use it to become independent from phosphoric rock mining and soluble phosphorous fertilizers.

Basically, the bazooka is a steel chimney of about four inches wide and 3 meters long that begins 15-20 cm from the ground. We build a small fire at the base of the chimney and surround it with cascarilla. Once the cascarilla begins to burn, we completely cover the fire with cascarilla so that the only air output is through the chimney, therefore burning very slowly and achieving high temperatures without bursting into flames.

Image 53. Layering cascarilla with bone meal, let it burn slowly, pyrolyze, from the inside out, with the resulting ash as phosphite. Photo by author.

Then we begin to layer the bone flour with the cascarilla and let it burn slowly into a brittle white ash: Phosphite. The smoke that comes out is dense and white, useful for drying wood and chasing flying insects away from closed environments such as a greenhouse. Phosphite production from bones is a very fun and cheap chemical process that has also called the attention of workers and neighbors, as they see the change in the result when applying these phosphites into compost beds, liquid biofertilizers, or directly into gardens with great results in improving plant immunity and general biological balance across plants, insects, and soil microorganisms.

The future of the planet is shit - Working with fermented manure

We have learned to love the presence of animals not only for their milk and meat (see subsection Animals above), but for the amazing power of transforming landscapes through their grazing patterns, and for one of the most amazing resources they give us in the work towards healthy soil: manure. The following are narrated experiences of a few products we do in different scales, adding a brief "recipe" summary of how to do this. We have learned this through various workshops, books, visits, and support by many allies[90]. But mostly we have learned by doing.

"En el rumen de una vaca se esconden los futuros bosques del mundo" (Restrepo 2019)

Have you ever wondered how an animal can grow over 300kg in body weight and build up flesh, bones, hide, hair, enzymes, milk from eating only pasture? It is a wonder beyond immediate comprehension, but its answer lies in the miracle of fermentation and the miraculous capacities that microorganisms have for transforming chemical elements into the building blocks of life. Ruminants have four chambers, also known as stomachs: rumen, reticulum, omasum, and abomasum. They graze a pasture, and a cud or bolus is formed, it is then regurgitated and chewed again, coming back to the rumen. The bolus is broken down into a pulp and through the aid of enzymes and microorganisms, mostly bacteria, present in saliva and resident microflora inside the rumen it is fermented and the nutrients in the bolus are separated and made available for absorption and use by the metabolism of the animal.

[90] We mention some directly in the narrations, but others in the acknowledgements.

Therefore, the manure of ruminant animals is a source of such an incredible array of microscopic alchemists that have the power to transform mineral elements into organically available components. That is the power we harness when we choose to ally ourselves to work with this rich resource, which is erroneously considered by modernity to be only a source of pathogenic microorganisms. There are countless ways to use manure, letting it be processed on the topsoil being the most common one, but for that the soil needs to have the sufficient diversity of microorganisms to process the manure and transform it into humus. Microorganisms can only live in the soil if there is sufficient moist organic matter to serve as their lodging. The three M's interacting with each other. Since we (farming humans) are living creatures with an explicit intention to transform the territories (farms) to sustain us, we search for a more active involvement in the transformation of minerals, organic matter, and microorganisms in the creation of a fertile subsoil ecosystem that can host a fertile ecosystem aloft.

The main idea of fermented manure products is to gather the allies within the rumen of cattle (in our case, although can be done with manure of any bovines, goats, sheep, giraffes, deer, gazelles, and antelopes), place them in a medium that encourages their reproduction and optionally expose them to mineral elements we want them to specialize in metabolizing. For their reproduction they need water, a source of energy (a carbohydrate), a source of protein or amino acids, and a nice temperature like the living body of an animal (between 37 and 42°C). Whether we want them to have oxygen available or not is variable. Some of these microorganisms are aerobic (use oxygen), some are anaerobic (don't use oxygen), and some are facultative (they can or cannot use oxygen). To obtain the largest diversity of microorganisms we usually do fermented manure broths anaerobically, allowing only for gas exchange, and therefore selecting only anaerobic and facultative organisms, that way we assure to eliminate all potential pathogens such as Escherichia Coli and others that are purely aerobic. Let us share the story and recipe of the main fermented manure recipe, the supermagro.

Supermagro

The supermagro is a liquid biofertilizer, obtained by anaerobic fermentation. It acts as a plant nutrient and can be used in all the phenological stages[91] of the crops. The product consists of fresh manure from cow, molasses, whey or raw milk, vegetable ash and natural water; may be added: yeast, green plant material, rock flour or minerals such as Zn, Mg, Cb, B, Cu, Ca, Mn, Na and Fe. Depending on availability of minerals and particular soil/crop needs, a nutritionally more complete formulation can be developed, or implement a more basic formulation.

The function of each ingredient, when preparing this biofertilizer, is to increase the synergy of the fermentation, and therefore increase the availability of nutrients for plants. The fresh manure of cow acts as a source of lignin, hemicellulose and microorganisms, it also contributes in smaller quantity: sugars, proteins, and starches. The molasses provides carbohydrates, which serve as energy to activate microbiological metabolism. Milk or whey also enriches the mix, as it is made up of proteins, fats, carbohydrates, vitamins, and valuable amino acids in the fermentation process. The mix can be improved by incorporating green plant material, ash, or minerals, which will be transformed by microorganisms and by the conditions of the fermentation. By adding yeast and/or fermented sugary drinks, in some communities they add guarapo (fermented sugarcane juice), or mishki (fermented agave juice, more known by its

Image 54. Sifting fresh manure, and gathering up other ingredients (molasses, phosphite, and magnesium and manganese sulphates. Photos by author.

[91] All stages of the plant: germination, vegetative growth, flowering, seeding, resprouting.

Mexican name Pulque), as a contribution of microorganisms to accelerate the fermentation process in the tank.

Supermagro increases the availability of micronutrients for the crop and the soil. Improves the natural fertility of the soil; by providing organic matter, it allows a greater ability to self-regulate physical parameters (texture, porosity, oxygenation, etc.), chemicals (pH, oxidation reduction potential (ORP) and electrical conductivity (EC), osmotic pressure, cation exchange capacity (CEC)) and biological diversity. Since its application is foliar[92], it acts almost instantly as it easily penetrates leaves and soils. Increases yields from the agroecological model and is an ally for the transition to a more sustainable model.

The instruments, equipment and materials that are required for its elaboration are cheap, common, and viable for home management, which facilitates their production. This bio-input does not require complicated technological instruments for its application. Through plant nutrition, the development of the plant is improved, which decreases the time between sowing and harvest stage.

The supermagro was invented in Brazil, by a farmer named Delvino Magro, who had the support of Dr. Sebastiaõ Pinheiro, researcher and agroecologist adviser of that country (Restrepo and Agredo 2020). The supermagro was made for the first time in Brazil, in small soft drink bottles (low scale), and when Delvino reported the results to a group of technicians and they verified the results, baptized the biofertilizer as Supermagro, with a certain contempt of Delvino Magro's invention, because they did not like the idea that a farmer could invent something that for vanity was their turn. After the great success of the biofertilizer, where just two liters of the fermented broth of cow manure, with an addition of minerals, had extraordinary effects on the crops, fame reached Delvino, to the point of offering lectures to other producers free of charge, which caused the supermagro to become a biofertilizer of production and international use.

[92] On the leaves

Image 55. Two kinds of air exchange systems. Left is improvised water trap with hose coming from tank lid; right is an air exchange valve attached to sealed tank. Photos by author.

Jairo Restrepo mentions that "there are no unique recipes, the idea of the supermagro only shows us the innumerable ways that exist to prepare a biofertilizer, enriched or not, with some or many mineral salts or rock flour. More than recipes, what counts here is the creativity of the people. This is a reality that obeys the different circumstances in which the producers, in the economic aspect (purchasing capacity), territorial (remoteness of point procurement) and training or consultancy (knowledge and processing skills)." (Restrepo and Agredo 2020)

Based on the above, the following is one example [within brackets you will find alternative ingredients or procedures, we have tried all of them] of a mineralized supermagro we use with particular application to our pastures:

Ingredients (for a 200L tank):

1. 50kg of fresh manure [50L of leached liquid product from a biodigester] mixed with 130L of fresh water [ideally non chlorinated water]
2. 10L of molasses [can use 3L less if at sea level or in warm climates]

Image 56. A good enough way to deliver supermagro to a pasture. Photo by author.

3. 7L of whey [3L of raw milk][93]
4. 5kg of grounded biochar [10kg of vegetable ash]
5. 2kg of yeast [1L of chicha, mishki, or other natural fermented drink]
6. 2kg of each mineral salt intended for use [2-6kg of rock flour][94]
7. 200L tank with hermetic seal lid modified for air exchange.

Preparation:

Image 57. From our initial 200L tanks with improvised air exchange valves to biofactory producing 1000L of supermagro a week. Photo by author.

1. Place the manure and water in the tank. Sift the manure as much as possible to avoid much fiber going into the tank.
2. Add all ingredients except for mineral salts. Mix thoroughly.
3. Close the tank while leaving a water trap, allowing gases to exit the tank but not to come in.
4. After 1 week, open the tank and add one of the desired mineral salts, add 2L of molasses, mix thoroughly and reseal.
5. After 1 week, repeat the same process adding every week a new mineral salt.
6. After 30 days of the initial inoculation, the enriched biofertilizer is ready to use. Sift while storing in airtight containers and store in a cool and dark place.
7. Use by applying the biofertilizer at a 5-10% concentration, to be sprayed or flooded depending on what is available.

[93] The first three ingredients make for a basic supermagro, ingredients 4 and 5 make for an improved product, and ingredient 6 make a custom mineralized product depending on the crop and soil destined for, the most complete version using a diverse mix of rock flour.
[94] We have missed the opportunity to go into fertilization with rock flour, but for reference of this very old technique you can see Hensel 1894.

Reproducing and activating Native Forest Microorganisms

This is another recipe for harnessing microorganisms, but the difference lies in the kind of organisms we are harvesting, reproducing, and applying to the soil and crops where we work. If the rumen of a cow has one of the most diverse, and biologically active, ecosystems of microorganisms that deal with the living, where could we find an equally, or more, diverse source of microorganisms? The answer is once again on the ground. For this recipe we search for functioning ecosystems with an intense microorganism activity: a healthy forest.

Image 58. Ignacio Simón demonstrating how and why to work with microorganisms as allies towards a healthy soil. Photo by author.

We visit the healthiest forest we can find, in our case we go to the ravines and streams of the cloud forests of the Andes, where native vegetation has been thriving for ages, and metabolism of organic matter into a constantly renewed forest is happening efficiently and rapidly. We gather the topsoil, or preferably just the mulch of the forest. We avoid all fresh green material, instead look only for brown leaves, rotting soft wood and branches, seed pods, insects, everything that is either black, brown, or white with mycelium. For our recipe, we will gather one full sack, to an approximate weight of 20 to 30kg of this forest mulch. The idea behind this recipe is simple, reproduce the wide diversity of microbial life that is decomposing and humifying the organic matter of the forest. For reproducing this flora and funga, we need again three basic ingredients: protein, sugar, and a controlled presence of moisture and air. Once we reproduce these Native Forest Microorganisms (NFM) in a solid presentation, we can use it this way for animal (human included) probiotic feed, and then we activate them in liquid form to apply them into crops and soils.

NFM – Solid form reproduction

Ingredients (for a 200L tank):

1. 30 kg of fresh native forest mulch. Sort out any green vegetation and any rocks or wood that is still hard.
2. 50kg of rice bran [wheat bran can also work, or other source of high protein material]
3. 3L of molasses, dissolved in no more than 5L of warm water.
4. 200L tank with hermetically sealed lid.

Image 59. Mixing forest mulch with rice bran, adding molasses, and compacting the mix in the tank with help of teenagers and barefooted toddlers. Photos by author.

Preparation:

1. Sift and grind forest mulch as much as possible. It's ok to leave browned and decomposing leaves and branches.
2. Mix forest mulch with rice bran without adding any water.
3. [Add 2kg of phosphites (see above, subsection Phosphites from bone) or 2kg of rock powder and 15kg of biochar (see above, subsection Making biochar)]
4. Once the solid ingredients are mixed, mix again while adding the molasses with water. This is trickier than it seems, as molasses with the bran tends to clump together. The best way is to kneel and mix with both hands while sweet water is slowly sprinkled as we mix. The final mixture needs to be as dry as possible. The more water that the mix holds, the larger the possibility of having bacteria dominating over fungal species, which is not optimal.

5. Place the mix in the tank while compressing it as it fills up, making sure no air pockets are left inside.
6. Fill the tank leaving at least 15cm from the lid, seal the tank, and leave it in a warm location without direct sunlight exposure for 30 days.

The solid form of microorganisms is ready to be used as a probiotic with high protein and energy content for animals. For calves 50g per day, preventing diarrheal diseases. For adult cattle, we have given up to 250g per day to cows in the final month before calving to improve their ruminating capacity. Pigs up to 50g per day, chickens, and turkeys 10 to 15g[95] per day.

This has also great (anecdotal) evidence of its use for humans. We have only used it for ourselves and our family, and with guidance from people like Ignacio Simón and Edwin Estrada that also do it only for their families. The product we obtain from the process described above is a 1st generation NFM, for humans we have taken an additional step in selecting further generations. We repeat the same process of preparation as above, but instead of using native forest mulch as our inoculant, we use the 1st generation NFM as seed. We have done this in 5-gallon (20L) buckets using the following preparation:

NFM – Probiotic breakfast powder for humans

Ingredients (for a 20L bucket):

1. 5 kg of solid NFM (1st generation), thoroughly sifted without any vegetable matter.
2. 10kg of rice bran.
3. 500mL of raw honey dissolved in no more than 200mL of warm water.
4. 20L bucket with hermetically sealed lid.

Preparation:

1. See steps 2, 4, 5, 6 from solid form NFM preparation above.

After 30 days of fermenting this preparation is a 2nd generation NFM, and the process can be repeated. We have obtained the best results and flavor from 3rd to 5th generation of NFM. We

[95] Similar referential dosages are suggested by Jairo Restrepo in his book (Restrepo and Agredo 2020) and through his workshops.

sprinkle a few grams of this microbiologically enriched bran in our yogurt and fruit, having a noticeable benefit in regulating digestion. This can be a possible route of future investigation, trying to assess the different array of microbiological diversity in this 1st and subsequent generations of NFM.

NFM – Liquid form activation

Ingredients (for a 200L tank):

1. 10-20 kg of solid Native Forest Microorganisms inside a canvas cotton bag.
2. 10L of molasses.
3. 10L of whey (or 3L of raw milk).
4. [2kg of phosphites or 2kg of rock dust]
5. 150L of clean water.
6. 200L tank with hermetic seal lid modified for air exchange.

Preparation:

1. Fill the 200L tank with water, molasses, whey, and rock dust, mix thoroughly.
2. Place the NFM mix inside the canvas cotton bag and close it, this will serve as a 20kg "tea bag", to brew a cold microbiological tea. Place this bag submerged inside the tank.
3. Seal the tank while leaving a water trap, allowing gases to exit the tank but not to come in.
4. Store in a warm location without direct sunlight exposure for 30 days.

This microbiological activation is perhaps one of the most beautiful preparations we have done, the abundance of life that begins to ferment in this sweetly smelling concoction is inspiring. Furthermore, we have witnessed that when our forest mulch source is from a wild area, far away from negative human impact, on the base of old and large trees, the results have been incredible. We share some photos to show these magical brews.

Image 60. The macro textures of microbial life. Liquid activated NFM. Photos by author.

After 30 days, we use this product diluted at a 5-10% concentration to be used as foliar sprayed application on crops and soils, also sprayed on compost piles to accelerate humification. We have applied combined spraying of a mix of supermagro, NFM, and sulphocalcic broth (see specific subsections) on pastures right after grazing and 15 days after grazing for incredible results. Results that are just beginning to be evidenced after 4 years of persistence, but the documentation and detailed record of the objective results (through quantitative soil testing, chromatography, and measurements of animal health and production) are not ready for the time of the writing of this project.

Image 61. Diego Ruano (green shirt) and Edwin Estrada (pouring NFM mix into tank), teachers and inspirations of working towards abundance of healthy soils. Photo by author.

However, we have tangible benefits already accounted for. We don't deal with any poisons, even though some chemicals we use require careful attention, no poisonings from the use of agrotoxics for people that collaborate with us or their families. Our children play around with our ingredients while we make the products, they bury themselves in the rice husks, taste the molasses, powder their faces with rice bran, even mischievously lick magnesium salts while we pretend not to see. When we spray these products on the field, the dogs run around trying to get a sweet taste of the fermented product, no one has to wear protective equipment to prevent poisonings, and the only side effect is a nice, fermented scent on clothes, skin, and hair. When an industrial fertilizer salesperson visits us at the farm, offering to give us the best soil fertility and productivity money can buy, we ask if what they sale is dangerous or poisonous for humans[96]. They claim that their super technological modern scientific new highly nitrogenated NPK is safe for everyone. We show them our products and then they usually claim that they are nice and ecological and everything but, “in reality,” they don’t provide the same results. We agree and tell them that our products provide better results, sustainable and consistent across time, and they actually build soil fertility, so we need progressively less applications over time. Also, we have challenged them to take the claim that their products are safe seriously. We’ve told them that if they drink a cup of their product, we will buy from them. No one has tried it. We have tried a cupful of liquid NFM with no problems; and have seen cows and dogs taste a sip of NFM and come back for more.

[96] We are only talking about N-P-K fertilizers, if a salesperson offers any agrotoxics such as herbicides, insecticides, fungicides, or other -cides, we walk them to the door without further conversation.

The Bokashi – a full meal for the soil

The bokashi is an organic fertilizer resulting from a fermentation process where mixtures of different organic materials are used in particular proportions to accelerate the decomposition process. Its elaboration is simple, and the materials can be obtained locally. Although they vary according to the availability in each region, the main elements are the following: dry manure (sheep-bovine-goat-poultry-equine), straw or dry harvest residues, rice husks, dark soil or compost, biochar or plant ashes, rock flour, yeast, molasses, and water.

Dry manure can come from many sources, from backyard animals or ruminant herds. Rice husk, cascarilla, improves the physical characteristics of organic fertilizers, facilitating aeration, moisture absorption and nutrient filtering. It also benefits the increase of the macrobiological and microbiological activity of the soil, while it stimulates the uniform and abundant development of the root system of the plants, as well as its symbiotic activity with the microbiology of the rhizosphere. It is a rich source of silicon, which favors vegetables, as it makes them more resistant to attacks by insects and diseases. Biochar improves the physical characteristics of the soil, such as its structure, which facilitates a better distribution of the roots, aeration and the absorption of humidity and heat (energy). Its high degree of porosity benefits the macro and microbiological activity of the soil, while it works as a "solid sponge" effect, which consists of the ability to retain, filter, and gradually release useful nutrients to plants, reducing the loss and washing of these in the soil. The carbon particles allow good oxygenation of the fertilizer, so that there are no limitations in the aerobic fermentation process. The rock flours, or rock dust, can be of different minerals, they gradually provide nutritional elements such as silicon, phosphorus, potassium, among others. They regulate the pH and improve the quality of the soil, increasing the availability of minerals for plants. The soil, which can be from a forest or replaced by compost, has the function of giving physical homogeneity to the fertilizer and distributing its humidity; adding it will increase the propitious environment for the development of the microbiological activity of the fertilizers and consequently achieve a good fermentation. The yeast and molasses dissolved in the water will form an inoculum that will speed up the fermentation of the compost. Molasses is a source of carbohydrates for the fermentation of organic fertilizers and favors the multiplication of microbiological activity; it is rich in potassium, calcium, phosphorus, magnesium and contains micronutrients, mainly boron, zinc, manganese, and iron.

Image 62. Flipping bokashi piles is always a team effort. Also notice how the first photo is of a first flip with materials raw, and the bottom image is s with the product almost ready, with materials "cooked" after 15 days. Photos by author.

Ingredients (for 1-ton final product[97]):

1. 7 (seven) 50kg sacks of dry manure (sheep, cattle, chicken manure, horses, goats)
2. 5 (five) 50kg sacks of rice husks
3. 7 (seven) 50-kilogram sacks of forest soil or compost
4. 7 (seven) 50kg sacks of straw or dry stubble (harvest remains) [this can be waived and completed with a few more sacks of rice husk and forest soil]
5. 2 (two) 50 kg sacks of biochar [plant ashes]
6. 1 sack of 50 kilograms of rock flour
7. 500 grams of yeast or 5 liters of mishki, pulque, chicha, cider, or other fermented drink
8. 2 liters of molasses
9. Natural, non-chlorinated water

Preparation:

1. One night before [or a few hours] dissolve the 2 liters of molasses

[97] It does not make much sense, due to the labor that this requires, to produce too small batches of bokashi. This recipe can be proportionally reduced by dividing everything by half or ¼ of the amount of material. The importance of having many bags of every material will be evidenced when describing the preparation, which is why we write 7 50kg sacks of manure instead of writing 350kg of manure. If reducing the amount of product, reduce the weight of

together with the 500 grams of yeast in 15 liters of warm water; mix homogeneously and let it rest.

2. Have all the materials and ingredients ready under a covered area to prevent the product from getting wet with the rain. Alternatively, be ready to cover it with a plastic tarp.
3. Now we prepare the bokashi as a lasagna of all our ingredients. The first layer of the ingredients will be spread, adding 1 sack of each: manure, rice husk, soil. As if seasoning your lasagna, pepper in some biochar, rock flour, and a sprinkle of the yeast/molasses water.
4. Continue with a second layer of the same ingredients which will be sprinkled again with the mixture of sweet water. Continue layer by layer until you finish all the ingredients.
5. A stack of layers of the ingredients will be formed, which must be stirred with the help of a pitchfork or shovel until a homogeneous mixture of all the ingredients is achieved. Switch metaphors from lasagna into a dough that needs to be thoroughly mixed.
6. Once the ingredients are mixed, the humidity will be checked; for this, take a handful of product and squeeze hand as a fist. It should not drip or feel dry, it should feel fresh and have a moldable consistency, if it drips add 1 or 2 sacks of earth or rice husks to reduce humidity.
7. Once the humidity of the pile has been verified, make sure it is a conical pile, not stretched out.
8. For the correct fermentation process, the fertilizer must be aerated, that is, it must be turned twice a day for the first 3-5 days, then once a day for another 10 - 12 days.
9. Each time the turning is made, the temperature must be verified with the help of a machete or thermometer, which will reach 50°C the first week, as the days go by, the bokashi temperature will decrease until it reaches an ambient temperature between 19 and 23°C. It is important NOT to add more water during the entire fermentation process.
10. Fermentation days may vary depending on the climate of each region; It is important that the temperature does not exceed 50°C, if this happens, a little water should be applied to help reduce it. You may have to turn it up even a third time if this happens.
11. As soon as the temperature has cooled and the ingredients look disintegrated and small, the bokashi is ready to be stored or applied. The ingredients are literally cooked with the invisible flame of fermentation.

Physical and chemical characteristics of the final product are important to verify quality and consistency. The scent must be of fermented sweetness with a slight smell of forest soil. If desired, measuring temperature and pH is a good idea. Around 20°C and between 7.8 and 8.8 is optimal. For use, the general recommendation is to apply one kilogram of bokashi for each square meter of surface, which means 10 tons per hectare. We have done many tons of bokashi in the past years, but we realized that it doesn’t make much sense to do them for pastures and large croplands. We do bokashi now exclusively for planting trees, and for horticultural gardens. We use 2kg of bokashi per tree, and it can be applied directly in the furrows, ridges or beds already planted, but at a distance of 15 cm from the plants. It can be applied to all crops. If you want to

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the sacks instead of the number. So, if your intentions are to produce half the amount, procure 7 25kg sacks of manure.

use it as a source of substrate for seedlings, you should use one kilo of bokashi in combination with 10 kilos of other ingredients such as mountain soil, compost, vermicompost, peat moss, perlite, etc. You can store bokashi for up to 3 years, but it is best not to let more than one year pass for its application. The ideal is to store it in sacks, in a cool and dry place, likewise label it to know the day of its preparation. DO NOT use fresh manure. We made a large batch from fresh poultry manure we got free, and it was a smelly, messy mistake. Do not let it get wet in the rain or let animals such as dogs, cats, or chickens come closer.

Bokashi's effects on plants are astounding. Being naïve and having a curiosity to "experiment," we have planted trees right next to each other, one with 2 kg of bokashi and other with raw food scraps, "all else being equal" (not really), and in less than a year the bokashi tree doubles in height. Now we just plant everything with bokashi. Instead of giving organic matter, minerals, and microorganisms to the soil for them to engage in relation there, through the fermentation process in bokashi the three M's come directly in touch and in balanced relation – a full meal for the soil.

Image 63. The mother with its bokashi-powered fava beans towering behind. Photo by author.

Brewing Sulphuric potions

There are many chemical compounds, potions, and concoctions that we have learned to do during our explorations of an autonomous agriculture that works towards healthy soils. We will go into only one Sulphur-based broth with many names: sulphocalcic, calcium sulfide, lime Sulphur. Calcium sulfide broth is a mineral product which can be prepared by farmers. It is used for the prevention and control of some pests and/or diseases; In addition to helping to overcome nutritional deficiencies of calcium and Sulphur in crops. It is composed of three elements: Sulphur, quicklime (calcium oxide), and water. The best lime used for this input is quicklime, which, unlike hydrated lime, is more efficient for the process of preparing the calcium sulfide broth, since it is of high purity[98]. The process of brewing the potion releases a paste at the end of its preparation, which is used to heal wounds on fruit trees due to poorly prepared pruning; likewise, to protect the grafts from any infection.

The ingredients are easily accessible and cheap, except for the quicklime. It is easy to prepare and apply. Organic agriculture certifications allow the use of this product, and it is helpful in the transition to an agroecological model.

Image 64. Sulfur and lime. Photo by author.

Ingredients

1. For 100 L of purified water
2. 19.2 kg of Sulphur and 8.6 kg of calcium oxide.
3. About 2.2:1 is the ratio (by weight) for compounding Sulphur and quicklime; this makes the highest proportion of calcium sulfide.
4. Quicklime is hard to obtain for us, and hard to store and manage, so we use calcium hydroxide (or hydrated lime). In that case, increase the lime by 1/3 or more. With the 192 g/L of Sulphur, use 115 g/L or more of lime.

[98] See section 3.1, especially subsections on Sulphur and Lime.

5. Stove, metal cauldron, and a stirring stick.
6. Dark plastic containers with lid to store broth [including a metal sifter and a funnel]
7. 200mL of vegetable oil [Used for storage]
8. Baumé hydrometer [Ideally]
9. Apron or overalls, face mask, safety googles.

Preparation:

1. This previous step is not required but helps with efficiency. 24 hours before making the preparation, mix the Sulphur in 10 liters of water until a homogeneous mixture is achieved. Likewise, 24 hours before making the preparation, quicklime is mixed with water. For this step, with extreme caution, add the quicklime in 3.5 liters of water; quicklime will chemically react with water through an exothermic reaction, up to the point of boiling, so be careful not to splash it to avoid burns. Wear gloves and a mask.
2. Alternatively, and especially if not using quicklime, we mix the Sulphur and the hydrated lime as powder in a plastic bucket.
3. Place the water on the cauldron and place it on the fire to boil. Additionally, be sure to keep some water in another cauldron to add to the boiling pot to keep volume constant. This water can also be used to suffocate the fire, in case of using firewood, once the product is ready to avoid overcooking.
4. Once water is close to boiling, add the powdered chemicals, or the buckets of dissolved chemicals, and boil at the highest possible temperature. The faster and more intense the boil, the better the result. Usually, the reaction takes place between 45 minutes to one hour, stirring and adding small amounts of hot water to compensate for evaporation.
5. You will know the process is complete when the yellow/whiteish color of the raw mix changes very markedly and rapidly into a dark brick, orange, wine color. At that moment, the fire should be turned off to avoid overcooking. The color will go dark yellow with tones of green if overcooked.
6. Stored in dark plastic containers, strained with a cloth and funnel, to eliminate solid parts or lumps. Once containers are filled to maximum, add 20-30ml of vegetable oil will be added to create a layer on top of the liquid, avoiding its contact with air and oxygen.
7. At the bottom of the cauldron tank there will be a thick blue/yellowish-green sediment called sulphocalcic paste, which must be kept in a wide-mouthed container (flask), add a tablespoon of cooking oil to avoid dehydration and volatilization. This paste is used to cure fruit tree pruning cuts or to apply to their trunks to prevent fungal infections.

It is recommended that the application of the broth be once it is cold and apply it in the morning before the sun hits or in the afternoon once the sun's rays have diminished. For each group of plants, the application dose is different. We work mainly on pastures and trees. For pastures we prepare it at a 2% concentration per hectare. That means that for a 400L spraying pump, where we are also adding NFM or supermagro we add 8 L of the sulphocalcic broth.

The wine or brick color like the one shown in the following image is characteristic of this broth, in addition to the fact that the aroma must be strong of Sulphur and the pH must be alkaline > 12. When we make this broth, everyone in the vicinity knows what we are up to, as the smell of Sulphur is hard to hide from. People claim that it smells of rotten eggs, but we disagree. Sulphur smells like Sulphur, and after a few batches we have learned to enjoy the smell. The sudden change of color when preparing this broth is surprising, and together with a good scale and measurement of the ingredients, are a good enough measurement that you have a decent quality product. To measure the concentration and quality of the broth, a Baumé hydrometer will be used to measure the density of the liquid; to take a reading, the instrument is allowed to float on the surface of the broth once it is cold; the preparation described in the procedure must give a solution with 32 degrees Baumé (Bé) which is equivalent to 25 or 26% dissolved Sulphur.

Image 65. Mixing the ingredients, enjoying the process, and the finished potion. Photos by author.

PART 4 – CONCLUSIONS; DEPARTURE POINTS FOR FUTURE WORK

To draw out final conclusions about this project, we propose to summarize the lessons obtained through the process and synthesize how we have approached the fundamental questions that guided our departure points.

We asked ourselves at the beginning: how can we study and understand living beings and the earth they are a part of? We also asked: Is another medicine possible? and is another agriculture possible? The answer to this was not straightforward, but manifold and complex.

The methodological approach we have used is based on a reimagination of description, what we have labelled description-as-method. Our method proposed to go beyond bare description, with an explicit intention to answer questions of relations, relations of people with their soil and their health; a method of description used as a strategic tool for answering questions of relations of people and health with their living milieu. The proposal of description-as-method sought to learn how to describe the relations of the living with their milieu, and as we and plant/soil-people learn them from herbs and soil.

Our method was developed at three junctures, and at each of these we can reflect on contributions that such pursuits can provide for scholarly research in the present and future. The first of these was a philosophical and historiographic reading of the concepts that pertain to our questions, mainly the theoretical foundations of hegemonic medical science. This effort, comprised within most of Part 2, except for chapter 2.4 and perhaps 2.7 and 2.8, and presents a contribution to medical geographies in the boundary of other social sciences such as science and technology studies, historiography of vitalist and mechanist conceptions, and a relational inquiry of medical knowledge.

The second area of the present work revolves on the comprehension and application of a methodological strategy to thinking life and its relations using a vitalist conceptualization of the life and the living, including the understanding of intuition as our intellectual approach towards our subject of study. This involves sections 2.4. We take vitalism from Canguilhem and Bergson, to elaborate it with contemporary anthropologists and social scientists of the ontological program (Viveiros de Castro, Kohn, Latour) and biologists (Varela, Maturana, Margulis) for making a case for a renewed version of vitalism as a pertinent and actual (vital) mode of inquiry into the life sciences, including medical science, biology, ecology, and agriculture. Bergsonian intuition plays a role here as well, and ours is an example that an epistemological approach beyond the inductive-deductive binarism is possible, and depending on the object of study, more adequately prepared to understand aspects of the world that lie beyond human intellect. We expand on sections 2.7 and 2.8 (adding authors such as Byung-Chul Han, Agamben, Foucault, Morton, and others) to apply such mode of inquiry into contemporary concerns where medicine meets political and ecological crisis of the 21st century. Particularly in response to the demands that our method of a vitalist approach, and its intuitive method of examination, we were confronted by the need to use ways of writing that are not commonly used for the doctoral dissertation genre. Imaginative and anecdotal writing of encounters with herbs and plant-people, giving voice to nonhuman or even inanimate beings, analyzing soil relations with artistic and poetic descriptions of its photographed representations, are all realized applications of what was proposed as creative description, poetic description, or description-as-method.

Finally, the application of such methodological endeavors into a practice that emphatically creates a different approach towards what it means to work for life and abundance. The creation of a “new” medical practice that we are coining as *medical agriculture*. The application of agroecological practices, informed by biological and chemical sciences, to work *for* living beings and build the health of the soil and the abundance of life and health it can sustain.

The project unfolds by the conjunction of these three moments: analysis of the historical evolution of the theoretical basis of medical science, exploration of a methodology of thinking adequately equipped to think the living organism within its milieu, and the practical application of these ideas on the work on soil health. These array of heterogeneous inquiries around a particular object of study, be it a theme, a concept, a place, or a set of relations is what makes geography of particular value at the vanguard of methodological thinking within academia, testing the boundaries of what it means to study or understand, and how to do it. We aspire to expand the present work, not necessarily by further exploration of the same themes, but by the method that geographical study offers, of studying heterogeneous phenomena as they entangle through existence and experience, and to discover, imagine, and create new existences and experiences.

LIST OF FIGURES

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